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COMPONENT MAGNETIC TEST FACILITY OPERATIONS AND TEST PROCEDURE MANUAL

By C. L. Parsons and C. A. Harris

Goddard Space Flight Center
Greenbelt, Maryland

July 1965

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

COMPONENT MAGNETIC TEST FACILITY OPERATIONS AND TEST PROCEDURE MANUAL

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SUMMARY

The physical features and operational functions of the Component Magnetic Test Facility at Goddard Space Flight Center are described and explained in detail. The test procedures have been prepared in particular for performing specific component magnetic field measurements on the OGO and IMP-I (Explorer XVIII) in order to obtain design control data pertinent to these two programs. However, the unique capabilities offered by this laboratory have also been used by several other programs. Mr. William D. Kenney was the principal engineer responsible for the design and development of this facility. He was assisted by Mr. Andrew G. Barr, electrical engineer, and by Messrs. Robert L. Bender and Leonard F. Robertson, III.

COMPONENT MAGNETIC TEST FACILITY

OPERATIONS AND TEST PROCEDURE MANUAL

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I INTRODUCTION

This manual has been prepared to meet the needs for a detailed facility operation and test procedure which can be used for instruction and reference. In addition, some sections can be used as a guide to fit the future needs of various programs. The facility was designed for component testing specifically for the OGO and IMP programs, and the test procedure mainly follows the requirements of these two programs. However, other programs such as Sounding Rocket, S-52, OAO, EPE-D, S-6, Alouette B, and ATS have utilized this facility and benefited from the unique capabilities available.

II FACILITY DESCRIPTION

A. BUILDING

The Component Magnetic Test Facility Building M-5 (Figure 1) is housed in a wooden frame building 20 x 20 x 20 feet in size. Due to the urgent needs of the OGO program, this building was constructed of immediately available conventional materials, i.e. wood, concrete, steel nails, steel bolts and composition roofing. Although the building contains magnetic materials, all nonmagnetic materials were used in the following items:

gimbals, heaters, detector boom and supports, coil frames and supports, detector holder, platform and stairs.

B. COIL SYSTEM

1. Dimensions and constants

The facility coil system consists of three sets of square orthogonal modified Helmholtz coils (Figure 2). The physical dimensions and computed constants of the coils are summarized in Table 1.

Table 1

Coil Data (Helmholtz Coils)

	X Coil	Y Coil	Z Coil
Side Length (feet)	14.0	13.7	14.3
Separation (feet)	8.4	8.4	8.4
Number of turns per loop	30	30	175
Number of turns -- total	60	60	350
Coil resistance (ohms)	35	35	130
Coil constant (gamma/amp)	10,785	10,785	62,912

2. Field Range and Resolution

The average field cancellation range for each coil is as follows:

Coil	Range (gamma)
X	0 - 20,000
Y	0 - 20,000
Z	0 - 60,000

With the external power supply current adjusting controls, it is possible to obtain $\leq$ 0.2 gamma resolution of the field generated by the coils. Under normal zero field operation, the average coil currents and field magnitudes are as follows:

Coil	Current (amps)	Field (gamma)
X	1.22	13,200
Y	1.32	14,200
Z1	0.89	Combined magnitude 56,000
Z2	0.89	

It should be noted that both the building and the Y coil axis are aligned to approximately 043° magnetic.

3. Zero Field Homogeneity and Gradients

When the coils are adjusted for zero field operation, the homogeneity for the center of the coil system within a sphere of 1 foot diameter is such that the field varies less than 50 gamma from the value at the center.

The field homogeneity for the system is as follows:

Spherical Diameter (feet)	Spherical Radius (inches)	Percentage Homogeneity
1	6	0.12
2	12	0.31
3	18	0.66

Field change along each coil axis (3 component data) is shown on the enclosed graphs (Figures 3 - 11), which indicate the zero field and ambient field gradients from the center of the coils to a distance of 16 inches in each of the X and Y directions and 14 inches in the Z direction. X and Y axis (3 component) graphs (Figures 12 - 13) are included which indicate that a gradient of less than 200 gamma per foot is maintained within a 1 and 1/2-foot radius of the center of the coils. Due to the structural limitations of the facility in the center of the coils, vertical axis measurements were possible only for a distance of 14 inches above and below the center.

4. Ambient Field Gradients

An ambient total field gradient of $\leq$ 14 gamma per foot is attributed to the fact that the facility is not completely free of nonmagnetic materials and equipment.

5. Coil Alignment

Since the building is not aligned North-South and East-West the coil system X and Y axes do not correspond to the geomagnetic axes of reference. The Y coil axis is set at an angle of 43° West of magnetic North. As a result the X and Y axis alignment is as follows:

X coil	South West	-	North East
Y coil	North West	-	South East

C. PERM-DEPERM COIL

1. Dimensions and Constants

The coil used for the 25 gauss exposure field and the 50 gauss deperming field consists of a single axis circular Helmholtz coil pair (Figure 2). The physical dimensions and coil constant of the coil are as follows:

Table 2

Coil Data (Perm-Deperm Coil)

Diameter (inches)	22.81
Separation (inches)	23.00
Number of turns per loop	676
Coil resistance (ohms)	14
Coil constant (gauss/amp)	5.2197

The coil is wired in parallel and is constructed so that the two coil frames can be removed from their position in the center of the coil system.

D. EQUIPMENT LIST (Refer to Figures 2 and 14)

1. Power Supplies

   a. Four Princeton Applied Research Model TC-602R (constant current)

   b. One Trygon Electronics, Inc. Model C160-160

   c. One Electro Products Laboratory Model EF

   d. One Variac autotransformer Model W50HM

2. Magnetometer Units

   a. Six Forster-Hoover Model MF-5050

   b. One Marshall Laboratories Model ML 172-2

3. Voltmeters

   a. One Hewlett-Packard Digital Model 405 CR

4. Printers

   a. One Hewlett-Packard Digital Model 561B or 560A

5. Magnetometer Probes

   a. Two Forster-Hoover triaxial probes Model MF-T-165

   b. Three Marshall Laboratories probes Model ML 173-1

6. Magnetometer Scanner (GSFC fabricated)

7. Two Gimbal Fixtures (GSFC fabricated)

8. One detector boom assembly with 2 extentions (GSFC fabricated)

9. Two triaxial probe holders (GSFC fabricated)

10. One Zenith Dial and Pointer (GSFC fabricated)

11. One triaxial system of 14' square Helmholtz coils

12. One single axis 4' circular Helmholtz coils

13. One three component probe positioner (GSFC fabricated)

14. One nonmagnetic tripod

E. CAPABILITY

1. The zero field feature, the accessibility of the coil system, and the gimbal arrangement serve to make the facility ideal for the magnetic field measurements parts, components, and subsystems. Although the gimbal is limited to packages 20 x 20 x 20 inches in size, it can be removed when larger size units are to be measured (data limitations then depend upon size and shape of unit). Although the facility has no automatic diurnal variation control, the measurement duration is such that the geomagnetic fluctuations are inconsequential. In addition to the zero field capability,

the field can be varied within the limits of paragraph B-2 or increased by reversing the direction of the field in the coils. In addition to magnetic field measurements, the facility has been for instrument calibration or "check-out" under the existing gradient conditions of the facility and where continuous diurnal variation control is not required.

III EQUIPMENT OPERATION

A. GENERAL INSTRUCTIONS

1. Princeton Applied Research power supplies (refer to Figure 15 for the front panel layout).

These power supplies are wired for 117 volt, 50/60 cps operation and are ready for use in the console. It is possible, but not desirable for this usage to rewire them for 234-volt operation.

The main power switch (6) is in the primary input line.

Meter panel lights (3) act as pilot lights, and should be lit when power is on.

The voltage sense switch (1) should be on external and the voltage control switch (5) should be on internal. The current range switch (2) should be on the two amp range.

A fine adjustment variable resistor (7) is installed in an external box that plugs into the negative sense and positive output terminal on the front of the power supply. This variable resistor will cause a ten gamma change in the X or the Y components and a thirty gamma change in the Z component. (Resolution - 0.1 gamma)

Increasing the knob marked voltage (4) from zero will decrease the field in the center of the coil system to zero. Further increase will then result in an increase in the field magnitude with a reversed field direction.

2. Trygon Electronics, Inc. Power Supply (Figure 16, Front Panel Layout).

This power supply is wired for use with 220-volt, 60 cycle. A special flexible cable of four number 6 wires is brought over from the main distribution panel (only three wires are used).

The output from the power supply goes through a relay on the variac panel to the Helmholtz pair used for exposure and deperm.

The jumper for the programming control should be on terminals 3 and 4 of the rear terminal block which allows front panel control (terminals 4 and 5 should not be jumpered).

The main power switch (4) is in one side of the primary input line and is a circuit breaker. The output should be switched off before the main power circuit breaker is switched off because transient voltages occur when the breaker is switched.

The current adjust (1) and voltage vernier (2) knobs should be turned completely clockwise. The voltage adjust (3) knob should start all the way counter-clockwise. A clockwise rotation of this knob increases the voltage and current.

3. Variac Autotransformer and Controls (Figure 17, Power Output Control Panel Layout).

The type W50 HM variac is normally used with a 220-volt input but has been wired for use with 110 volts, 60 cycles. When wired for 110 volts input, the maximum current rating is ten amperes (a rating which should not be exceeded). The upper left switch (4) on the panel is the main power switch for the variac.

The upper right hand switch (3) operates a relay that switches the Helmholtz coil from the output of the power supply (Trygon) to the output of the variac with up for variac or ac current and down for the dc power supply.

The lower switch (1) on the panel switches from the output of the dc power supply to the two banana terminals just below the switch with up for the power supply and down for the terminals. The down position of this switch is normally used to break the connection from the output of the power supply. When using the dc perm field, select the proper field direction (2). Figure 18 indicates the coil control circuit.

4. Hewlett-Packard Digital Voltmeters (Figure 19, Front Panel Layout).

   The H.P. voltmeters are wired for 115-volts, 60 cycles operation. It is possible but not desirable to rewire them for 230-volt operation.

The main switch (1) is in one side of the primary input line with a pilot light (2) to the right of the switch.

The range switch (5) should be in the automatic position and the sampling rate (6) should be fully clockwise without going to the external position. A noticeable click is heard when the sampling rate goes into the external position.

To calibrate the instrument depress the calibrate button (3) and adjust the calibrate screw (4) until the voltmeter reads the value stamped on the calibration decal. An internal secondary voltage standard is used and the input is disconnected when the calibrate button is depressed.

5. Forster-Hoover Magnetometer (Figure 20, Front Panel Layout).

   a. Introduction

      These magnetometers operate on 115-V, 60 cycle and are ready for use in the console. This is a three axis magnetometer with a triaxial probe. The three electronics units operate from a single power supply which is located in one of the units. There is a power switch for each unit, however, the unit with the power supply must be turned on before the other units can be turned on. For the operation of the magnetometer, all three units should be on with detectors plugged in.

b. Normal Operation (zero field)

For normal operation in the console the filter switch (10) should be in the off position, the sensitivity switch (11) should be in the X1 position, and the readout switch (5) should be in the MO position.

To check the mechanical zero of the front panel meter (1), tap the meter with a pencil eraser before the equipment is turned on and align the pointer of the meter with the zero mark using the mirror to prevent parallax. Any adjustments needed are made with the screwdriver adjustment below the meter (2).

After a warmup period of one-half hour the magnetometer is ready for use. When the magnetometer is to be used for zeroing the field, the compensation

("- off +") switch (9) should be in the OFF position. Switch the range switch (12) from the zero position toward the 1 range (with the probe in the center of the coil system) while adjusting the current in the coils and keeping the needle near zero.

c. Ambient Field Operation

When the magnetometer is to be used in other than zero field, the probe is placed in position with range switch (12) in the zero position. The range switch is then switched toward the one scale until the meter deflects (greater than 20 scale divisions but less than 100). If the deflection is to the left or minus, the compensation ("- off +") switch (9) is switched to the "-" position. If the deflection is to the right or a plus deflection, switch to the "+" position. The 100's (13), 10's (14) and 1's (15) compensation switches are then adjusted until the range switch can be switched to the one scale. Final adjustment is then made by bringing the meter to zero with the ten turn compensation potentiometer (16).

B. CALIBRATION

The magnetometer can be calibrated on the one, ten, hundred, and thousand ranges only. The calibration on the one range calibrates the one, two, and five ranges. The ten range calibration calibrates the ten, twenty and fifty ranges. The hundred range calibration calibrates the one hundred, two hundred and five hundred ranges and the thousand range calibration calibrates the thousand range only. With the range switch (12) on the desirable range and the meter (1) on zero, depress the calibrate button (3) and adjust the calibrate adjustment screw (4) until the meter reads full scale or one hundred divisions. Release the calibration button and see that the meter returns to zero.

C. EXTERNAL OUTPUT

When an external readout is used, as in the console, the external readout will replace the meter. In the case of the Hewlett-Packard Voltmeter the zero reading should be between -.003 and +.003 and the full scale reading should be calibrated prior to the calibration of the magnetometer.

D. EQUIPMENT ACCURACY AND STABILITY

1. Power Supply

   Princeton Applied Research Corporation Model TC-602R

   Accuracy -- ±0.01% of full scale (60 millivolts) Stability -- ± 0.001% ±0.001% ± stability of resistor over a period of 8 hours (normal operation time)

2. Voltmeter

   Hewlett-Packard DC Digital Voltmeter

   Accuracy -- ±0.2% of reading + 1 count

3. Magnetometer

   Forster-Hoover Magnetometer Model MF 5050

   Accuracy -- ±1.0% on the 0-100, 1000, 10,000 and 100,000 gamma ranges when calibrated ±3.0% on all other ranges when calibrated

   Stability -- ±1.0%

IV FACILITY OPERATION

A. FACILITY PREPARATION

1. Turn on all facility test equipment (Figure 14) -- allow at least 30 minutes warmup period.

It should be noted that the person who operates the gimbal and handles the packages should at all times be magnetically clean (i.e. remove belt buckles, rings, watches, etc.). In order to ascertain that the individual is non-magnetic, he should check himself by approaching the triaxial probe and observing any magnetometer field change.

2. The Princeton Applied Research Power Supplies should be set to approximately the correct voltages and currents during the warmup period. The settings that are on the power supplies from the previous day should be adequate. Normally the settings should be as follows:

Power Supply	Volts	Amperes
X	39.3	1.22
Y	39.9	1.32
Z1	56.2	0.89
Z2	53.8	0.89

3. The Electro Products Laboratories Power Supply Model EF should be set at 28-volts.

B. NULLING EARTH'S FIELD TO ZERO

1. Place a triaxial probe (refer to this as zero field probe) in the gimbal that is in the center of the coil system, centering on the X detector with the X detector facing out of the gimbal rather than to the side of the gimbal. Clamp the probe in the gimbal.

2. Remove all inputs from the Hewlett-Packard digital voltmeter. Connect the output from the Forster-Hoover magnetometer electronics unit that is associated with the X detector to the input of the Hewlett-Packard voltmeter.

3. Locate the second triaxial (identify this one as the measurement probe) on the radial boom at the measurement distance (if this distance is not known select a suitable distance such as two or three feet).

4. Check the alignment of the X detector in the gimbal. Turn the X detector electronics sensitivity selector to one scale. Align the X detector (in zero field probe) along the X axis of the coils and adjust the current in the X coils until the voltmeter output is near zero. The compensator for the X detector electronics should be in the off position.

5. Repeat this procedure for the Y and the Z axis by aligning the X detector along the Y and Z coil axes, respectively.

6. Align the X detector along the Y axis. Note the reading (plus Y) then flip the X detector 180° in either azimuth or zenith and note the reading (minus Y).

7. Adjust the current in the Y coils until the voltmeter reads halfway between the two readings. Continue flipping the probe 180° and adjusting the Y coil until the +Y and the -Y readings agree within 0.005%.

8. Compensate the detector (measurement probe) which is aligned along the Y axis with the compensation circuit to zero.

9. Repeat steps 6, 7, and 8 for the X and the Z axis.

10. Remove the zero field probe from the gimbal.

11. The measurement probe is now in the zero field reference and the compensation circuits should not be readjusted until probe is removed.

C. CALIBRATION

1. Remove all inputs from the Hewlett-Packard voltmeter and connect the output of the magnetometer for the

measurement probe through the scanner to the input of the voltmeter. Use the scanner to select each component, i.e. X, Y or Z.

2. Push the voltmeter calibration button and then adjust the calibrating screw until the voltmeter reads the value that is on the calibrate decal. Release the button.

3. Account for any geomagnetic field changes by adjusting the current in the coils until the measuring probe electronics reads zero $\pm 0.003\%$ on the voltmeter output.

4. With the scanner on the Y component selection mode, depress the magnetometer electronics calibrate button and adjust the electronics calibrate adjustment screw until the voltmeter reads +1.00. Release the calibrate button and check to see if the voltmeter reads zero ± 0.003. If not, depress the calibrate button again, readjusting if necessary.

5. Advance the scanner to the next electronics unit by depressing and releasing the button on the scanner control panel. Repeat steps 3 and 4 for this electronics unit.

6. Advance the scanner again as in step 5 and repeat steps 3 and 4 for the third electronics unit.

7. Advance the scanner to the position for the Y electronics unit.

8. All the magnetometer electronics units should be on the one scale for the previous steps unless it is known before hand that any higher scale is to be used in the test. Calibration on the one scale is used for the one, two and five scale. Calibrate on the ten scale for scales 10, 20, and 50. Calibrate on the 100 scale for scales 100, 200, and 500.

V ASSEMBLY TEST PROCEDURE

A. MEASUREMENT DISTANCE

1. Measure the maximum linear dimension of the assembly.

2. Determine the measurement distance (feet). This distance is equal to or greater than three times the maximum linear dimension of the measured assembly.

3. Locate the radial component measurement detector so that the distance from the center of the gimbal to the

center of the triaxial probe corresponds to (2) above. Before moving the triaxial probe rezero the field (X, Y, and Z coils) then, after the triaxial probe is moved, recompensate the X, Y, and Z electronics for zero field.

4. If the assembly has been measured and the measurement distance previously determined, or if a program specifies a particular measurement distance, steps 1 and 2 can be omitted.

B. ASSEMBLY PREPARATION

1. Determine the spacecraft (orbital) axes of the assembly by any of the following means: Test action request, available photographs, drawings, or contact the test coordinator. As each new assembly is received, axes reference photographs are to be taken.

2. Place centering tapes on the four sides of the assembly (mid-points) and mark the tapes so that the assembly can be centered in the gimbal.

3. Adjust the height of the lower gimbal plate so that when the assembly is placed in the gimbal, the center of the assembly coincides with the gimbal center.

4. Place the assembly in the gimbal maintaining identical assembly spacecraft axes and coil system axes orientations.

5. Position the assembly in the gimbal so that the positioning tapes and the gimbal center lines are aligned.

6. Clamp the assembly in the gimbal.

7. Check the assembly for slippage and secure the protective gimbal straps.

C. RADIAL COMPONENT MAGNITUDE DETERMINATIONS

1. With the test assembly in the gimbal (Figure 21) rotate the gimbal in zenith and azimuth in order to locate the maximum radial component (plus peak), recheck with additional zenith and azimuth rotation. Then record the gimbal azimuth and zenith angles for the peak.

2. First, record the peak magnitude (angle), return the gimbal to the zero reference position (zero), and then record the zero reference magnitude.

3. Repeat step 2 and then check the difference between the peak and zero magnitudes. If these values agree within 0.3 gamma continue to step 4 if not, repeat step 2.

4. Next, rotate the gimbal and locate the minus peak. Record these angles. Note: When the azimuth angle of rotation exceeds 180°, use 180° rotation in zenith instead.

5. Repeat the measurement steps 2 and 3 in order to determine the magnitude of the minus peak.

6. Unclamp the gimbal to release the assembly.

7. With the assembly in the zero reference position, record the magnitude (assembly-in), then remove the assembly and record the background (assembly-out) magnitude.

8. Repeat step 7 in order to obtain 0.3 gamma agreement.

9. Once the magnitude of the assembly is known for the zero reference position (difference between out-and-in), this magnitude, when added to the mean difference between the zero position and the peak position, determines the actual peak magnitude

<u>Example 1</u> - Positive Reference Magnitudes

	Positive Peak		Negative Peak	
Peak (angle)	4.5	4.7	-4.2	-4.2
Reference(o)	1.3	1.3	1.3	1.3
Difference	+3.2	+3.4	-5.5	-5.5
Mean	+3.3		-5.5	

	Positive Peak (contd)			Negative Peak (contd)
Assembly in		1.3	1.1	
Assembly out		0.2	-0.2	
in vs out		+1.1	+1.3	
Mean		+1.2		
Actual peak magnitude	+1.2			+1.2
	+3.3			-5.5
	+4.5			-4.3

Example 2 - Negative Reference Magnitudes

	Positive Peak				Negative Peak	
Peak (angle)	5.2	4.9			-4.5	-4.7
Reference (o)	-3.5	-3.7			-3.2	-3.1
Difference	+8.7	+8.6			-1.3	1.6
Mean	+8.7				-1.4	
Assembly in			-3.1	-3.3		
Assembly out			0.5	0.7		
in vs out			-3.6	-4.0		
Mean			-3.8			
Actual peak magnitude	-3.8				-3.8	
	+8.7				-1.4	
	+4.9				-5.2	

10. The magnitude which is reported is the maximum (positive or negative) magnitude which was measured.

D. TEST DATA WORK SHEET

1. As the test is conducted, the measurement data is transcribed to a work sheet which includes the following:

   (a) General Information

   Project, test item, model, serial number (if available), type of test, and test data

   (b) Measurement Data

   Measurement distance, azimuth and zenith angles of the maximum (positive and negative) radial component, maximum radial component magnitude, type of measurement (initial, post exposure, etc.), and face measurement magnitudes

E. GIMBAL AZIMUTH AND ZENITH ANGLES

1. Figure 22 indicates the normal gimbal zenith zero reference position for the test assembly. The measurement probe is located along the +Y axis of the coil system. As the assembly is rotated in a clockwise direction and pivots on the X axis, the zenith position angle increases.
2. Figure 22, also indicates the normal gimbal azimuth zero reference position for the test assembly. In the azimuth position, the measurement probe (+Y) is at 90°. When

the assembly is rotated in azimuth, the plane of rotation varies according to the zenith angle of the assembly.

3. Since the gimbal has only two axes of rotation, it is not possible to directly relate the gimbal angles to the actual assembly angle. In order to determine the direction of the moment of the assembly, the following procedure can be utilized:

   (a) Locate the assembly so that the detector lies along the +Y axis of the assembly (Figure 22). Now rotate the assembly (clockwise) in zenith with the X axis as the axis of rotation. Then, with the assembly fixed at the gimbal zenith angle position, move the detector horizontally in azimuth about the assembly (refer to azimuth diagram Figure 22). If the azimuth gimbal angle is less than 90°, rotate the detector in a clockwise direction, decreasing in degrees towards zero. If the azimuth gimbal angle is greater than 90°, rotate the detector counterclockwise, beginning with 90° and increasing to a maximum of 180°. This now locates the direction of the maximum radial component of the assembly with respect to the detector.

4. Some assemblies, due to their size of shape, cannot be placed in the gimbal so that the assemblies' spacecraft axes (+X, +Y, and +Z) correspond to the coil system axes (+X, +Y, +Z). When this occurs, it then becomes necessary to transpose axes. For these cases, the reference position of the assembly is denoted so that gimbal angle and package angle correlation is possible.

VI DC MAGNETIC FIELD MEASUREMENTS

A. OGO EXPERIMENTAL ASSEMBLIES

Magnetic field measurements are performed on the OGO spacecraft experiment assemblies in order to obtain design control data. These tests are performed on the prototype and flight units as required. The prototype assemblies are measured at the beginning (Initial Test) and conclusion (Final Test) of the environmental test sequence. The flight units, all of which receive a final test, are measured initially only when the prototype unit had an extrapolated field magnitude of 500 gammas or greater at a distance of 12 inches. These tests measure the permanent, induced, and stray field magnetization of the assemblies and consist of the following:

1. Permanent Magnetization

   The permanent magnetic field of the assembly is measured when the unit is first received (initial perm) by placing the unit in zero field and measuring the maximum radial component. If required, the assembly is exposed to a dc field of 25 gauss and then remeasured (post exposure). This field represents the maximum ambient field to which the assembly might be exposed during the environmental test sequence, i.e. vibration exciters. Subsequently, the assembly is depermed (demagnetized) in a 50 gauss ac field which is gradually reduced to zero. Then, the remanent magnetization (post deperm) of the assembly is measured.

2. Induced Magnetization

   The induced field measurements are performed by applying a known field (0.26 gauss) along one axis of the coil system and then measuring the magnitude of field induced in the assembly. Since this measurement includes the permanent plus induced magnetization, it is necessary to subtract the permanent magnitude in order to obtain the actual induced magnetization of the assembly.

3. Stray Magnetization

Stray field measurements are conducted by observing the change in magnetic field external to the assembly when it is turned on and then off. This difference represents the actual stray field which is generated by the assembly when in operation. The prototype experimental assembly magnetic test requirements are detailed in T&E Specification No. S-4-101 Revision A, paragraph 4.2 dated February 8, 1963 which are as follows:

4.2 Magnetic Test -- Measurement shall be made of the permanent, induced, and stray magnetic field of each experiment assembly. All data from these tests shall be maintained for design control information.

4.2.1 Initial Determinations -- At the start of the environmental exposure sequence, the experiment shall be checked for permanent, induced, and stray effect at a distance of at least three times the maximum linear dimension of the assembly. The inverse cube shall be applied for extrapolation to a distance of one foot. If the extrapolation for each of these fields is equal to 100 gamma or less, no further testing shall be required until completion of the environmental test sequence. Where this value is exceeded, the test shall be continued by measuring the magnetic field at a distance of approximately six times the aforementioned distance. If the extrapolation for permanent or induced magnetic field again exceeds the 100 gamma value, the experiment shall be exposed to a dc magnetic field representing the maximum field it is likely to experience during its lifetime (25 gauss unless otherwise determined). After this exposure, the experiment permanent magnetic field shall be measured and the experiment de-magnetized to its initial state or less.

4.2.2 Final Determinations -- At the end of the environmental exposure sequence, the permanent magnetic field shall be measured at a distance of at least three times the maximum linear dimension of the assembly. The inverse cube law shall be applied for extrapolation to a distance of one foot. If the extrapolation exceeds the initial value (paragraph 4.2.1) by more than 20 gamma, or if the extrapolation now exceeds 100 gamma, the experiment shall be exposed to a dc magnetic field of 25 gauss (unless previously exposed as in paragraph 4.2.1) and remeasured. In any case, the experiment shall now be de-magnetized (if necessary) to its initial value or less.

The Flight Experimental Assembly magnetic Test requirements are detailed in T&E Specification No. S-4-201, paragraph 4.5 dated March 14, 1964 which are as follows:

4.5 Magnetic Test -- At the completion of the other environmental exposures, measurement shall be made of the permanent, induced, and stray magnetic field of each experiment. All data from these tests shall be maintained for design control information. All measurements shall be extrapolated to a distance of one foot using the inverse cube law.

The extrapolated data shall be compared to that taken during testing of the prototype experiment (Ref.: T&E Specification S-4-101). Obvious discrepancies shall be reported immediately to the OGO Project Manager.

NOTE: Experiment assemblies which exhibited fields of 500γ or greater at any time during the prototype test program shall be subjected to applicable field measurements prior to other environmental exposures.

4.5.1 Procedure -- Following the other environmental exposures, the experiment assembly shall be exposed to a dc magnetic field (25 gauss unless otherwise determined). The assembly shall then be checked for permanent effect at a distance of at least three times the maximum linear dimensions of the assembly. Following this measurement, the experiment shall be de-magnetized to its initial state or less as determined during testing of the prototype experiment. The assembly shall then be checked for induced and stray (experiment operative) effect at a distance of at least three times the maximum linear dimensions of the assembly. Following these measurements, a recheck of the permanent moment shall be made.

The OGO experimental assemblies are measured in accordance with these specifications by following the magnetic test procedure as detailed in parts 1 and 2 of this section.

PART 1 OGO Prototype Experimental Assemblies
- INITIAL TEST -

A. Initial Permanent Magnetization

1. With the assembly in zero field, measure the maximum positive and negative radial component following the radial component magnitude determinations procedure in Section V, paragraph C.

2. Measure the magnetic field magnitudes for each of the faces of the assembly (+Y, -Y, +X, -X, +Z, -Z). Agreement within

0.5 gamma between the face and reference magnitudes is sufficient.

3. Record the measured data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating by the inverse cube law the maximum value measured.

4. If the field at 12 inches exceeds 100 gamma, second distance measurements (6 times the maximum linear dimensions at the assembly) are to be performed.

5. Before the measurement probe is moved, check the zero field for drift, adjusting if necessary, then move probe to the second distance. Readjust the step compensation switches as required in order to re-zero the magnetometers.

6. Measure the maximum radial component (repeat steps 1 and 3).

7. Return the probe to the initial measurement position (three times the maximum linear dimension) and readjust the zero field compensation (reverse procedure of step 5).

8. In the event the extrapolated magnitude at 12 inches exceeds 500 gamma, the test coordinator is to be informed.

B. Induced

1. With all the magnetometer sensitivity switches on zero, reverse the Y coil (field changed from compensating to aiding earth's field) by throwing the Y coil reversing switch from cancel to double. (Effective applied field 0.26 gauss).

2. Make a note of the position of the magnetometer compensation control settings (Y axis magnetometer electronics). Return this magnetometer to the one scale by adjusting the step compensators as needed.

   NOTE: Do not change the fine adjust compensating potentiometer.

3. Measure the maximum (plus and minus) radial component at the angles previously determined from initial perm measurements of paragraph A, by following the measurement procedure of Section V, paragraph C.

4. Measure the magnitudes for each of the faces of the assembly (+Y, -Y, +X, -X, +Z, -Z).

5. Since these measurements are induced plus permanent magnetization, algebraically subtract the permanent magnetization, values obtained in paragraph A, from the

induced plus perm magnitudes just obtained. These magnitudes represent the induced magnetization of the assembly for an applied field of 0.26 gauss.

6. Record the induced data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating the maximum value measured.

7. If the field at 12 inches exceeds 100 gamma, then, second distance measurements are to be performed.

8. When second distance measurements are made, move the probe to the second distance (6 times the maximum linear dimension), and then adjust the magnetometer compensation as needed.

9. Measure the maximum radial component (repeat steps 3, 5, and 6).

10. Return the probe to the initial measurement position, with the magnetometer in the zero position, return the Y coil current reversing switch to cancel and return the compensators to their original positions.

11. When the maximum induced plus permanent radial component has a direction other than that of the maximum permanent

radial component, it will be necessary to determine the initial permanent radial component magnitude for this direction in order to compute the induced magnetization.

C. 25 Gauss Exposure

1. When the induced or permanent magnetic field of the assembly exceeds 100 gamma at a distance of 12 inches, the assembly is exposed to a dc field of 25 gauss. If the the extrapolated field is less than 100 gamma, the 25 gauss exposure sequence is omitted in the initial test.

2. Before exposing the assembly, determine the location of the permanent magnetic moment of the assembly by referring to the angles recorded in paragraph A. Also note the polarity of the moment.

3. With the assembly in the gimbal, align the moment along the axis of the exposure coils so that both fields are in the same direction.

4. Turn all the magnetometers to the zero position.

5. Connect the coils to the dc power supply and close the coil switch.

6. Turn on the power supply applying 5 amperes of current to the coils (coil constant 5 gauss/amp). Normal exposure time at least 3 seconds.
7. Turn the current off and break the circuit. Turn the magnetometers to the appropriate sensitivity scale for measuring the magnitude of the assembly. Check the assembly to see if the direction of the peak has shifted. If the peak has shifted more than 10 degrees, then repeat the 25 gauss exposure (step 6) on the new peak.
8. With the assembly in zero field, measure the maximum radial component following the procedure in Section V, paragraph C.
9. Measure the magnetic field magnitudes for each of the faces of the assembly (+Y, -Y, +X, -X, +Z, -Z).
10. Record the measured data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating the maximum value measured.
11. If the post 25 gauss exposure magnitude at 12 inches exceeds 500 gamma, inform the test coordinator.

D. Deperm

1. With the assembly removed from the gimbal, re-zero the field. Replace the assembly in the gimbal and then clamp the assembly in the gimbal.

2. With the assembly turned to the maximum exposure angle (paragraph C 3) and the magnetometers turned to the zero position, apply 10 amperes of 60 cycle ac current to the Helmholtz deperming coils. Decrease this current slowly to zero.

3. Turn the magnetometers to the one scale and locate the direction of the maximum radial component.

4. If the direction of the maximum radial component has shifted and, or, its magnitude is not below 95% of the maximum post exposure magnitude, repeat step 2 in the new direction or on the peak radial component.

5. When it is not possible to deperm the assembly below 95% of the post exposure magnitude, ascertain if the assembly contains components with permanent magnets such as relays which would not deperm in the 50 gauss field.

6. Measure the maximum radial component, following the procedure in Section V, paragraph C.

7. Record the measured data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating the maximum value measured.

E. Stray

1. With the probe located at the measurement distance (3 X MLD), connect the power cables to the assembly and then clamp the assembly in the gimbal.

2. After the experimenter or his representative has determined that the assembly is operating and the voltage and current adjustments have been completed, the stray field measurements can be made.

3. Record the operational voltage and current magnitudes for the assembly.

4. The stray field measurements are then made by recording the field magnitude with the assembly operating and with the assembly non-operative (power-on vs power-off).

5. Obtain information from the experimenter as to possible current changes which would occur while the assembly is functioning, i.e., calibration, step functions, stand-by or transmit conditions. In the event several such modes of

operation occur, record the maximum stray field magnitude condition.

6. Measure the stray field (radial component) along each face of the assembly (+X, -X, +Y, -Y, +Z, -Z).

7. Select the assembly face which has the highest magnitude, then shift the gimbal in azimuth and zenith to locate the peak stray field magnitude and direction.

8. When the extrapolated magnitude at 12 inches exceeds 100 gamma, second distance measurements (6 X MLD) of the maximum radial component of the stray field are to be performed.

9. If the stray field magnitude at 12 inches exceeds 500 gamma, then inform the test coordinator.

FINAL TEST

A. Initial Permanent Magnetization

1. With the assembly in zero field, measure the maximum positive and negative radial component following the radial component magnitude determinations procedure in section V, paragraph C.

2. Measure the magnetic field magnitudes for each of the faces of the assembly (+Y, -Y, +X, -X, +Z, -Z). Agreement within 0.5 gamma between the face and reference magnitude is sufficient.

3. Record the measured data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating the maximum value measured.

B. 25 Gauss Exposure

1. Refer to the initial magnetic test data and if the extrapolated field magnitude (measured in paragraph A) exceeds the initial value by more than 20 gamma or exceeds 100 gamma, the assembly is exposed to a dc field of 25 gauss.

2. Before exposing the assembly, determine the location of the permanent magnetic moment of the assembly by referring to the angles recorded in paragraph A. In addition, refer to the initial test post exposure data in order to locate the maximum moment. Also note the polarity of the moment.

3. With the assembly in the gimbal, align the moment along the axis of the exposure coils so that both fields are in the same direction.

4. Turn all the magnetometers to the zero position.

5. Connect the coils to the dc power supply and close the coil switch.

6. Turn on the power supply applying 5 amperes of current to the coils (coil constant 5 gauss/amp). Normal exposure time at least 3 seconds.

7. Turn the current off and break the circuit. Turn the magnetometers to the appropriate sensitivity scale for measuring the magnitude of the assembly. Check the assembly to see if the direction of the peak has shifted. If the peak has shifted more than 10 degrees then repeat the 25 gauss exposure (step 6) on the new peak.

8. With the assembly in zero field, measure the maximum radial component following the procedure in section V, paragraph C.

9. Measure the magnetic field magnitudes for each of the faces of the assembly (+Y, -Y, +X, -X, +Z, -Z).

10. Record the measured data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating the maximum value measured.

C. Deperm

1. If the assembly has been exposed (paragraph B) or extrapolated initial permanent magnetization magnitude (paragraph A) exceeds the initial test magnitude, the assembly is to be depermed.

2. With the assembly removed from the gimbal, rezero the field. Replace the assembly in the gimbal and then clamp the assembly in the gimbal.

3. With the assembly turned to the maximum exposure angle (paragraph C. 3) and the magnetometers turned to the zero position, apply 10 amperes of 60 cycle ac current to the Helmholtz perming coils. Decrease this current slowly to zero

4. Turn the magnetometers to the one scale and locate the direction of the maximum radial component.

5. If the direction of the maximum radial component has shifted and, or, its magnitude is not below 95% of the maximum post exposure magnitude, repeat step 2 in the new direction or on the peak radial component.

6. When it is not possible to deperm the assembly below 95%

of the post exposure magnitude, ascertain if the assembly contains components with permanent magnets such as relays which would not deperm in the 50 gauss field.

7. Measure the maximum radial component following the procedure in section V, paragraph C.

8. Record the measured data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating the maximum value measured.

PART 2. OGO Flight Experimental Assemblies
- INITIAL TEST -

Initial test measurements are conducted on those experimental assemblies which had fields of 500 gamma or greater (distance - 12 inches) at any time during the prototype test program, i.e., permanent, induced, or stray field magnetization. When such measurements are conducted, refer to the Final Test procedure for Flight Assemblies.

FINAL TEST

A. Initial Permanent Magnetization

1. With the assembly in zero field, measure the maximum positive and negative radial component following the radial

component magnitude determinations procedure in Section V, paragraph C.

2. Measure the magnetic field magnitudes for each of the faces of the assembly (+Y, -Y, +X, -X, Z, -Z). Agreement within 0.5 gamma between the face and reference magnitudes is sufficient.

3. Record the measured data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating the maximum measured value.

B. Induced Magnetization

1. With all the magnetometer sensitivity switches on zero, reverse the Y coil (field changed from compensating to aiding earth's field) by throwing the Y coil reversing switch from cancel to double. (Effective applied field 0.26 gauss).

2. Make a note of the position of the magnetometer compensation control settings (Y axis magnetometer electronics). Return this magnetometer to the one scale by adjusting the step compensators as needed.

   NOTE: Do not change the fine adjust compensating potentiometer.

3. Measure the maximum (plus and minus) radial component at the angles previously determined from initial perm measurements of paragraph A, by following the measurement procedure of section V, paragraph C.

4. Measure the magnitudes of each of the faces of the assembly (+Y, -Y, +X, -X, +Z, -Z).

5. Since these measurements are induced plus permanent magnetization, algebraically subtract the permanent magnetization, values obtained in paragraph A, from the induced plus perm magnitudes just obtained. These magnitudes represent the induced magnetization of the assembly for an apply field of 0.26 gauss.

6. Record the induced data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating the maximum value measured.

7. When the maximum induced plus permanent radial component has a direction other than that of the maximum permanent radial component, it will be necessary to determine the initial permanent radial component magnitude for this direction in order to compute the induced magnetization.

C. 25 Gauss Exposure

1. Determine the direction of the permanent magnetic moment of the assembly (refer to initial perm measurements).

2. Note the polarity of the moment and with the assembly in the gimbal, align the moment in the direction of the exposure field.

3. Turn all the magnetometers to the zero position.

4. Connect the coils to the dc power supply by closing the open coil switch.

5. Turn on the power supply, applying 5 amperes of current to the coils for at least 3 seconds.

6. Turn off the power supply and break the circuit. Turn the magnetometers to the appropriate sensitivity scale for measuring the magnitude of the assembly. Check the assembly to see if the direction of the peak has shifted. If the peak has shifted more than 10 degrees, repeat the 25 gauss exposure (step 5) on the new peak.

7. Measure the maximum radial component following the procedure in Section V, paragraph C.

8. Measure the magnetic field magnitudes for each of the faces of the assembly (+Y, -Y, +X, -X, +Z, -Z).

9. Record the measured data on the data sheet and determine the magnitude of the field at 12 inches by extrapolating the maximum measured value.

D. Deperm

1. With the assembly removed from the gimbal, rezero the field. Replace the assembly in the gimbal and then clamp the assembly in the gimbal.

2. With the assembly turned to the maximum exposure angle (paragraph C. 3) and the magnetometers turned to the zero position, apply 10 amperes of 60 cycle ac current to the Helmholtz perming coils. Decrease this current slowly to zero.

3. Turn the magnetometers to the one scale and locate the direction of the maximum radial component.

4. If the direction of the maximum radial component has shifted and, or, its magnitude is not below 95% of the

maximum post exposure magnitude, repeat step 2 in the new direction or on the peak radial component.

5. When it is not possible to deperm the assembly below 95% of the post exposure magnitude, ascertain if the assembly contains components with permanent magnets such as relays which would not deperm in the 50 gauss field.

6. Measure the maximum radial component following the procedure in section V, paragraph C.

7. Record the measured data on the data sheet. Determine the magnitude of the field at 12 inches by extrapolating the maximum value measured.

E. Stray Field Magnetization (Experiment Operative)

1. With the probe located at the measurement distance (3X MLD), connect the power cables to the assembly and then clamp the assembly in the gimbal.

2. After the experimenter or his representative has determined that the assembly is operating and the voltage and current adjustments have been completed, the stray field measurements can be made.

3. Record the operational voltage and current magnitudes for the assembly.

4. The stray field measurements are then made by recording the field magnitude with the assembly operating and with the assembly non-operative (power-on vs. power-off).

5. Obtain information from the experimenter as to possible current changes which would occur while the assembly is functioning, i.e., calibration, step functions, stand-by or transmit conditions. In the event several such modes of operation occur, record the maximum stray field magnitude condition.

6. Measure the stray field (radial component) along each face of the assembly (+X, -X, +Y, -Y, +Z, -Z).

7. Select the assembly face which has the highest magnitude then shift the gimbal in azimuth and zenith to locate the peak stray field magnitude and direction.

8. Record the direction and magnitude of the stray field and then extrapolate this magnitude to 12 inches.

F. Post Stray Permanent Magnetization

1. At the conclusion of the stray field measurements, the permanent moment of the assembly is re-measured (paragraph A step 1).

2. Record the measured data on the data sheet and extrapolate the maximum measured value to 12 inches.

3. If the extrapolated magnitude (post stray perm) exceeds the post deperm magnitude then repeat the post deperm test sequence, paragraph D steps 1-3.

4. At the conclusion of these measurements, the results for the flight assembly should be compared with the prototype unit. If any obvious discrepancies are noticed, they should be reported to the test coordinator.

B. IMP COMPONENTS

Magnetic field measurements are performed on the IMP spacecraft components in order to obtain design control data. The measurements are performed at the beginning (initial) test) and conclusion (final test) of the environmental test sequence. The initial test consists of measurments of the permanent (initial, post exposure, and post deperm), induced 0.26 gauss applied field), and stray field magnetization of the component as specified in the IMP Environmental Test Specification for Components GSFC-S-320-IMP-1, paragraph 4.2, which are as follows:

4.2 INITIAL MAGNETIC FIELD MEASUREMENT. Magnetic Field Measurements shall be taken at 18 and 36 inches. The requirements shown in Table II shall be applicable to components undergoing both Design Qualification and Flight Acceptance measurements.

TABLE II

Initial Magnetic Field Measurement

Condition	Applied Field (gauss)	Magnetic Field Disturbance (gamma) 18 inches** Max.***	36 inches** Max.
(1) Perm Initial	0	8	1
Post 25 gauss exposure	0	32	4
Post 50 gauss Deperm	0	2	0.25
(2) Induced	0.26	2	0.25
(3) Stray Power "on" vs Power "off"	0	4	0.50

*Design goal for the integrated spacecraft is that the total magnetic field disturbance for all sources aboard the spacecraft shall not exceed 1/2 gamma measured at the magnetometer sensors in their final extended positions.

**Measured from Geometric Center of component.

***If the Magnetic Field Disturbance measurement at 18 inches is 10 gamma or less the magnetude at 36 inches may be computed using the inverse distance cubed relationship. For large packages, which preclude measurements at 18 inches, measurements shall be made at 36 inches and 48 inches, to determine the rate at which the magnetic field diminishes with distance.

The final test is then performed at the conclusion of the environmental test sequence as specified in paragraph 4.9 which is listed below.

4.9 FINAL MAGNETIC FIELD MEASUREMENT

Magnetic Field Measurements shall be taken at 18 and 36 inches. The requirements shown in Table XVII shall be applicable to all components and are also applicable for both Design Qualification and Flight Acceptance measurements.

TABLE XVII

Post-Test Magnetic Field Measurement

Condition	Applied Field (gauss)	Magnetic Field Disturbance* (gamma)*	
		18 inches**	36 inches**
Perm	0	2	0.25

* The measured magnetic field disturbance for any component shall not exceed the value measured in 4.2 Table II condition (1).

** Measured from geometric center of component.

The IMP components are measured in accordance with these specifications by following the detailed Magnetic Test Procedure.

INITIAL TEST

A. Initial Permanent Magnetization

1. With the component in zero field and the detector 18 inches from the geometric center of the component, measure the maximum positive and negative radial component by following the radial component magnitude determinations procedure in Sect. V Para. C. (The 18 inch measurements are performed with the IMP gimbal).
2. Measure the magnetic field magnitudes for each of the faces of the component (+Y, -Y, +X, -X, +Z, -Z). Agreement to within 0.4 gamma between the face and reference magnitude is sufficient.
3. Record the measured data on the data sheet. If the magnetic field disturbance of the component exceeds 10 gamma, remeasure the component at 36 inches.
4. Before the measurement probe is moved, check the zero field for drift, adjusting if necessary, then move the probe to the second distance. Readjust the step compensation switches as required in order to rezero the magnetometers.

5. Measure the maximum radial component (step 1).

6. Return the probe to the initial measurement position (18 inches) and readjust the zero field compensation (reverse procedure of step 4).

B. Induced

1. With all the magnetometer sensitivity switches on zero, reverse the Y coil (field changed from compensating to aiding earth's field) by throwing the Y coil reversing switch from cancel to double. (Effective applied field 0.26 gauss).

2. Make a note of the position of the magnetometer compensation control settings (Y axis magnetometer electronics). Return this magnetometer to the one scale by adjusting the step compensators as needed. Note: Do not change the fine adjust compensating potentiometer.

3. Measure the maximum (plus and minus) radial components at the angles previously determined from initial perm measurements of paragraph A by following the measurement procedure of Section V paragraph C.

4. Measure the magnitudes for each of the faces of the assembly (+Y, -Y, +X, -X, +Z, -Z).

5. Since these measurements are induced plus permanent magnetization, algebraically subtract the permanent magnetization values obtained in paragraph A, from the induced plus perm magnitudes just obtained. These magnitudes represent the induced magnetization of the assembly for an applied field of 0.26 gauss.

6. Record the induced data on the data sheet. If the field exceeds 10 gamma, then second distance (36 inches) measurements are to be performed.

7. When second distance measurements are made, move the probe to the second distance and then adjust the magnetometer compensation as needed.

8. Measure the maximum radial component (repeat steps 3, 5, and 6).

9. Return the probe to the initial measurement position, with the magnetometer range selector switch in the zero position, return the "Y" coil current reversing switch to cancel and the compensators to their original positions.

10. When the maximum induced plus permanent radial component has a direction other than that of the maximum

permanent radial component, it will be necessary to determine the initial permanent radial component magnitude for this direction in order to compute the maximum induced magnetization.

C. 25 Gauss Exposure

1. In order to expose the component to the 25 gauss field, determine the location and polarity of the permanent magnetic moment of the component by referring to the angles and magnitudes recorded in paragraph A.

2. With the component in the gimbal, align the moment along the axis of the exposure coils so that both fields are in the same direction.

3. Turn all the magnetometers to the zero position, then with the coils connected to the dc power supply, apply 5 amps of current to the coils. Normal exposure time at least 3 seconds.

4. Turn the current off and break the circuit. Turn the magnetometers to the appropriate sensitivity scale for measuring the magnitude of the component. Check the component to see if the direction of the peak has shifted.

If the peak has shifted more than 10 degrees then repeat the 25 gauss exposure (step 6) on the new peak.

5. With the component in zero field, measure the maximum radial component following the procedure in Sect. V, paragraph C.

6. Measure the magnetic field magnitudes for each of the faces of the component (+Y, -Y, +X, -X, +Z, -Z).

7. Record the measured data on the data sheet. If the post 25 gauss exposure magnitude at 18 inches exceeds 10 gamma remeasure the component at 36 inches.

D. Deperm

1. With the component removed from the gimbal, rezero the field. Replace the component in the gimbal and then clamp the component in the gimbal.

2. With the component turned to the maximum exposure angle (paragraph C-2) and the magnetometers turned to the zero position, apply 10 amperes of 60 cycle ac current to the Helmholtz perming coils. Decrease this current slowly to zero.

3. Turn the magnetometers to the one scale and locate the direction of the maximum radial component.

4. If the direction of the maximum radial component has shifted and, or, its magnitude is not below 95% of the maximum post exposure magnitude, repeat step 2 in the new direction or on the peak radial component.

5. When it is not possible to deperm the assembly below 95% of the post exposure magnitude, ascertain if the component contains parts with permanent magnets such as relays which would not deperm in the 50 gauss field.

6. Measure the maximum radial component following the procedure in Sect. V, Para. C.

7. Record the measured data on the data sheet. If the magnitude at 18 inches exceeds 10 gamma remeasure the component at 36 inches.

E. Stray

1. With the probe located at the measurement distance (18 inches) connect the power cables to the component and then clamp the component in the gimbal.

2. After the experimenter or his representative has determined that the component is operating and the voltage and current adjustments have been completed, the stray field measurements can be made.

3. Record the operational voltage and current magnitudes for the component.

4. The stray field measurements are then made by recording the field magnitude with the component operating and with the component non-operative (power-on vs power-off).

5. Obtain information from the experimenter as to possible current changes which would occur while the component is functioning, i.e., calibration, step functions, stand-by or transmit conditions. In the event several such modes of operation occur, record the maximum stray field magnitude condition.

6. Measure the stray field (radial component) along each face of the component (+X, -X, +Y, -Y, +Z, -Z).

7. Select the component face which has the highest magnitude then shift the gimbal in azimuth and zenith to locate the peak stray field magnitude and direction.

8. When the magnitude at 18 inches exceeds 10 gamma, second distance measurements (36 inches) of the maximum radial component of the stray field are to be performed.

FINAL TEST

A. Permanent Magnetization

1. With the component in zero field, and the detector 18 inches from the geometric center of the package, measure the maximum positive and negative radial component by following the radial component magnitude determinations procedure in Sect. V Para. C.
2. Measure the magnetic field magnitudes for each of the faces of the component (+Y, -Y, +X, -X, + Z, -Z). Agreement to within 0. 4 gamma between the face and reference magnitudes is sufficient.
3. Record the measured data on the data sheet. If the magnetic field disturbance of the component exceeds 10 gamma, remeasure the component at 36 inches.

B. Deperm

1. Deperm the component as outlined in the initial test procedure Para. D, Steps 1-5.

2. Measure the remanent magnetic field disturbance of the component (initial test procedure Para. D, steps 6 and 7).

C. PARTS AND SAMPLES-MAGNETIC TEST PROCEDURES

Generally speaking, the magnetic field measurement requirements of parts and samples will fall into the following confines:

1. Measurements of parts and samples in order to determine the magnitude of magnetic field disturbance.
2. Measurements of a group of parts in order to select the least magnetic.
3. Measurements of parts and samples in order to determine if they are relatively or completely non-magnetic.

Due to these requirements, the following two test procedures are utilized in the magnetic field measurements of parts and samples.

1. General - magnitude requirements (categories 1 and 2)
2. Special - non-magnetic requirements (category 3)

Those items tested under the General Parts and Samples Test Procedure are normally measured at a distance of 12 inches while the non-magnetic items are measured by placing the object as close to the probe as possible.

PART 1 - General Parts and Samples Test Procedure -

A. Permanent Magnetization (Initial, Post Exposure, Post Deperm)

1. Locate the detector 12 inches from the center of the gimbal. Either the hand held or gimbal rotation and peaking methods are used depending upon the size and shape of the component. When the peak radial component magnitude is indeterminate at 12 inches, select the appropriate measurement distance (6, 4, 3, 2 inches) at which the item can be measured. These measurements require that the item be hand held.

2. Rotate the part to be measured (azimuth and zenith rotation) and locate the maximum radial component. For gimbal measurements, follow the radial component magnitude determinations procedure in Sect. V Para. C. In the case of hand held measurements, note the direction of the peak (plus and minus) and record the magnitudes directly, in vs out.

3. Measure the item initially (Initial Perm) then expose the item to an exposure field of 25 gauss directed along the primary permanent magnetic moment of the item. After the exposure, remeasure the item by following the initial perm measurement

procedure of step 2 to determine the maximum post exposure radial component magnitude.

4. At the completion of the post exposure determination deperm the item with a 50 gauss ac field. Remeasure the item (step 2) in order to obtain the post deperm radial component magnitude.

B. Induced Magnetization

1. Ordinarily, the induced magnetic moment of a part or sample is not measured. In the event that induced measurements are to be performed, step 2 outlines the procedure.

2. Place the sample in the 0.26 gauss applied field as used for component tests. Align the item so that the maximum radial component is in the direction of the detector and applied field. Measure the permanent plus induced magnetization. Algebraically subtract the permanent magentization (previously measured in paragraph A) in order to determine the induced magnetization magnitude.

C. Stray Field Magnetization

1. When stray magnetic field data are required for particular parts and samples, they are obtained by measuring the

magnetic field change which occurs when the item is energized (power off to on or power on to off).

2. With the item at the measurement distance, determine the magnitude and direction of the maximum radial component stray magnetic field by rotation of the item. (Procedure similar to OGO and IMP components stray magnetic field measurements.)

PART 2 - <u>Special Parts and Samples Test Procedure -</u>

A. Initial Permanent Magnetization

1. With the detector in zero field, select the appropriate radial component detector. Bring the item to be measured as close to the surface of the probe as possible.

2. Determine the direction and magnitude of the maximum magnetic field disturbance of the item by hand rotation.

3. Record the in vs out magnitude and the peak direction.

B. 25 Gauss Exposure

1. Expose the part to a field of 25 gauss

2. Measure the part (paragraph A steps 2 and 3)

C. High Field Exposure

1. A more complete test for non-magnetic properties is performed by exposing the item to fields in excess of 100 gauss. The high field exposure is achieved by bringing the item to be measured into contact with a permanent magnet of known magnitude.

2. At the completion of the high field exposure, measure the item (paragraph A steps 2 and 3)

D. Post Deperm

1. Deperm the item in a 50 gauss ac field.

2. Measure the item (para. A steps 2 and 3).

3. In the event the part does not deperm and it is desired to further demagnetize the part, utilize the 400 gauss demagnetizer to deperm the item.

4. Remeasure the item by repeating step 2.

E. Induced Magnetization

1. To measure the induced magnetic field disturbance of the item, follow the general parts induced magnetic field measurement procedure (Part 1, Para. B, step 2).

F. Stray Field Magnetization

1. Refer to general parts stray field measurement procedure (Part 1, Para. C, steps 1 and 2)

D. SOLAR PADDLES

The solar paddle permanent and induced magnetization measurements are performed in a manner similar to the OGO experimental assemblies measurements by utilizing the OGO size gimbal. In the case of the stray field measurements, it is necessary to use the special solar paddle fixture and obtain x, y and z component data.

Permanent Magnetization

1. Locate the measuring detector 24 inches from the center of the gimbal. Adjust the gimbal height to center the paddle.
2. Place the solar paddle in the gimbal (include the two foam rubber protective pads), center the paddle in the gimbal and then clamp the gimbal.
3. Measure the maximum radial component (refer to general procedure of Sect. V, Para. C). At the 24 and 36 inch distances measure the initial perm, post exposure, and post deperm magnitudes.

4. In the event the paddle has a high perm field, locate the principal sources by conducting surface measurements (refer to special parts and samples test procedure) Sect. VI, Para. C).

Induced Magnetization

1. With the paddle in an applied field of 0.26 gauss, measure the maximum perm plus induced radial component magnitude (refer to general parts and samples induced magnetic field measurement procedure Sect. VI, Para. C).

Stray Field Magnetization

1. Set up the array of sun guns as shown in the solar paddle test layout (figure 24). Mount the paddle in the holding fixture and position the paddle in the center of the coils. Locate the probe 24 inches North of the center of the coils. Turn on the sun guns and position for maximum illumination, then turn off the sun guns.

2. Turn on the sun guns and activate the paddle. Measure the x, y, and z component magnitudes (power on) then deactivate the paddle and measure the background field (power off). At the completion of the background measurements, turn off the sun guns.

3. Next rotate the paddle 180° in azimuth and repeat the measurements (step 2).

4. Rotate the probe 90 degrees and measure the stray field disturbance at this position (step 2).

5. Repeat step 3.

6. Rotate the paddle 90 degrees in zenith and repeat steps 2 and 3.

7. With the probe positioned at the maximum stray field measurement position and at a distance of 36 inches from the center of the paddle, repeat the stray field measurements of step 2.

VII AC MAGNETIC FIELD MEASUREMENTS

A. OGO EXPERIMENTAL ASSEMBLIES

1. The measuring distance is first selected for the assembly to be tested and is as follows:

Assemblies	Distance (feet)
Body and SOEP	5.5
EP-4	6.0
OPEP and EP	4.5

2. Set up the triaxial probe holder and position the probes at the measuring distance centering on the assembly (center of gimbal).

3. Turn on the Marshall Laboratories (figure 23) ac magnetometer switch (1) - no warm-up period necessary - switch the meter selector switch (3) to BATT. If the meter reads greater than half scale, the batteries are in good condition. (For less than half scale readings, replace the batteries).

4. Turn off all ac operating equipment including the overhead lights.

5. With the assembly test equipment ON but, not connected to the test assembly, record the ambient background field. Record the meter readings (volts) for each of the frequency channels (4) for each of the probes (total of 18 measurements) also include the sensitivity (2) and voltage (3) settings.

6. With the assembly mounted in the gimbal, energize the assembly. Selecting the maximum power operating mode, record the meter readings (volts) for each of the

frequency channels (3, 10, 30, 100, 300, and 1000 cps) for each of the probes (X, Y, and Z). These readings plus the sensitivity and voltage settings are tabulated in an Assembly On Column.

7. If any of the measurements on any axis exceeds 0.5 volts (High Sensitivity) for any frequency band, a photograph of the output of the wideband amplifier shall be taken for that measurement. This output is provided on the external jack marked OUT.

8. If the maximum power mode is considered to be the normal mode of operation, no further measurements of the time varying magnetic fields of the assembly are required. If the maximum power operating mode of the assembly is not considered to be the normal mode of operation, repeat steps 6 and 7 with the assembly in the normal operating mode.

Figure 1–Component Magnetic Test Facility Building

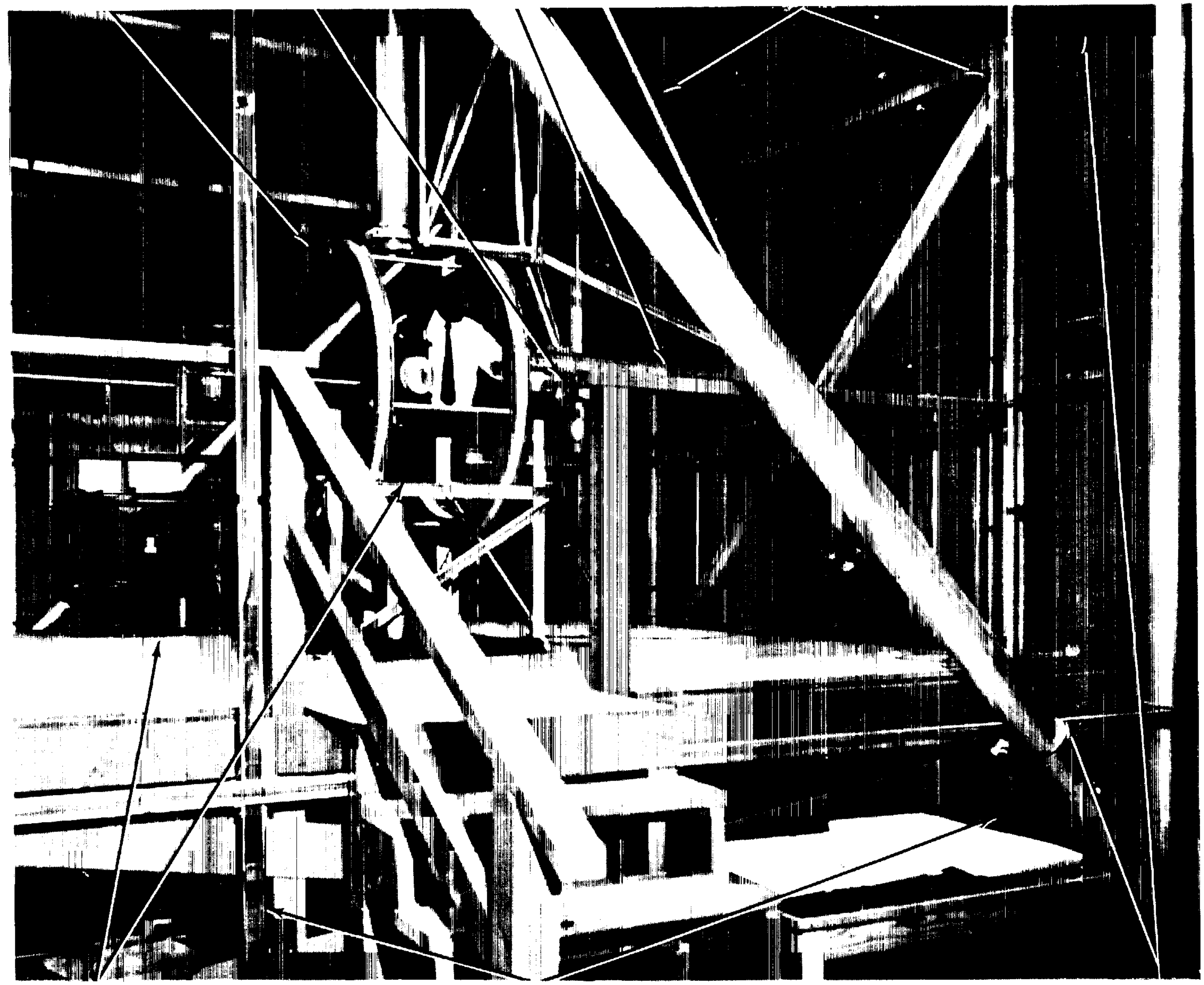

Figure 2–Component Magnetic Test Facility

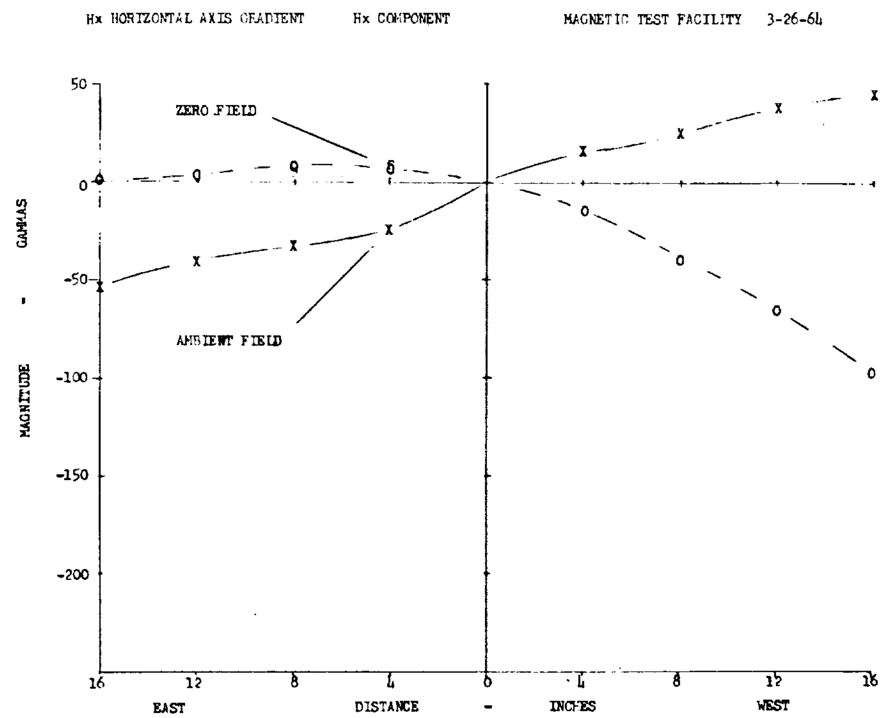

Figure 3–X Coil Axis – X Component Gradient

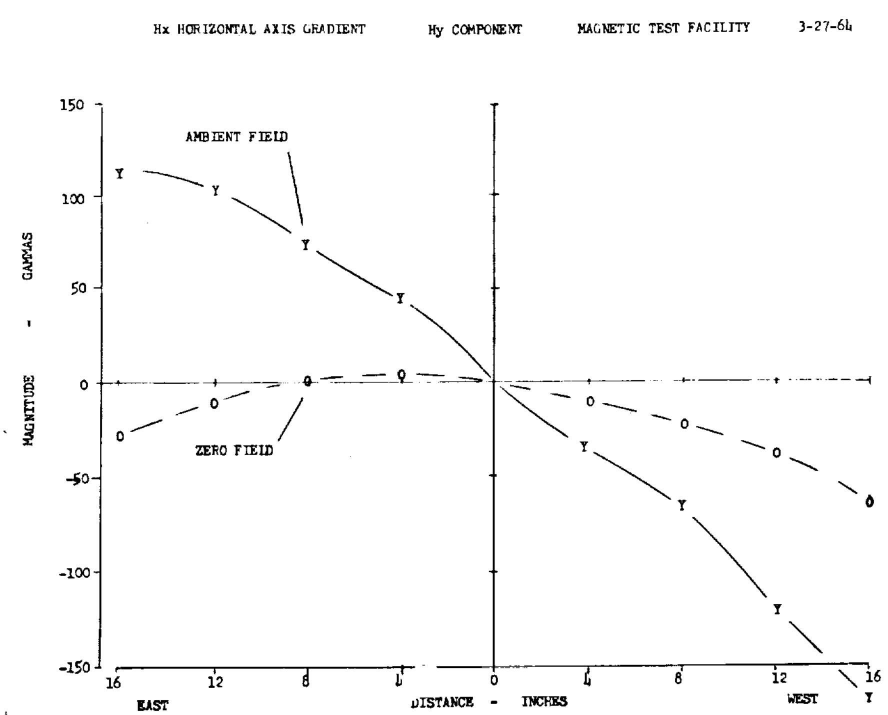

Figure 4–X Coil Axis – Y Component Gradient

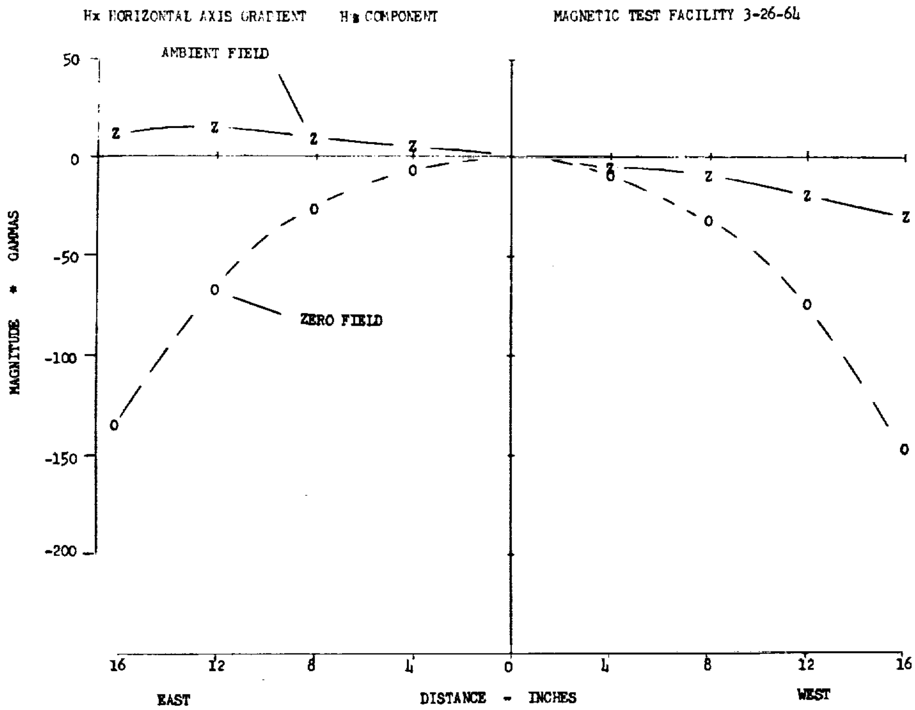

Figure 5–X Coil Axis – Z Component Gradient

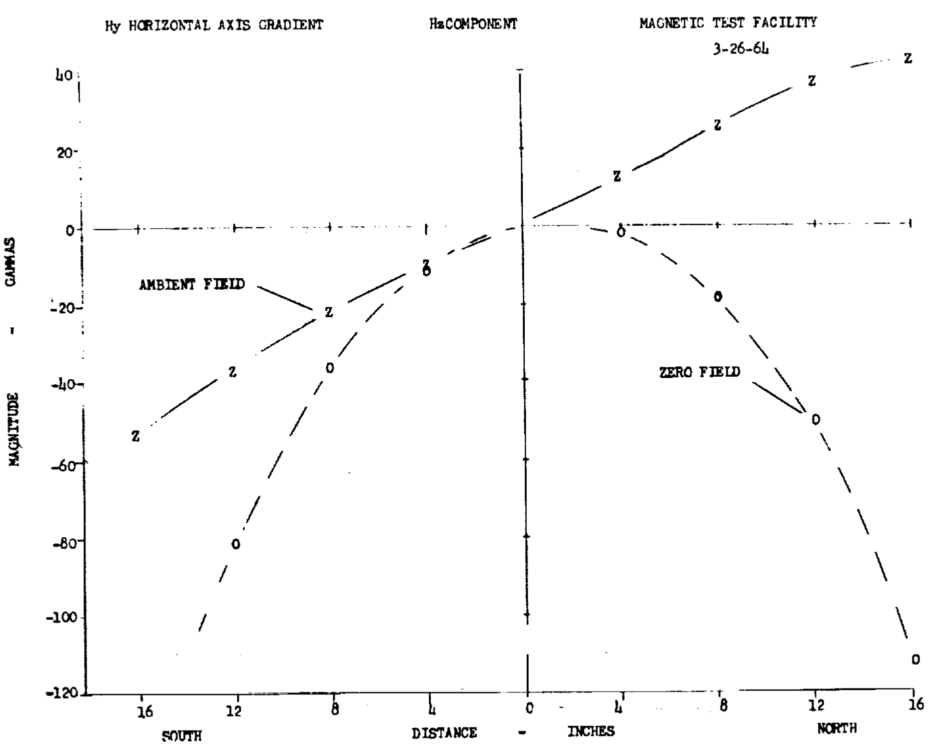

Figure 6– Y Coil Axis – Z Component Gradient

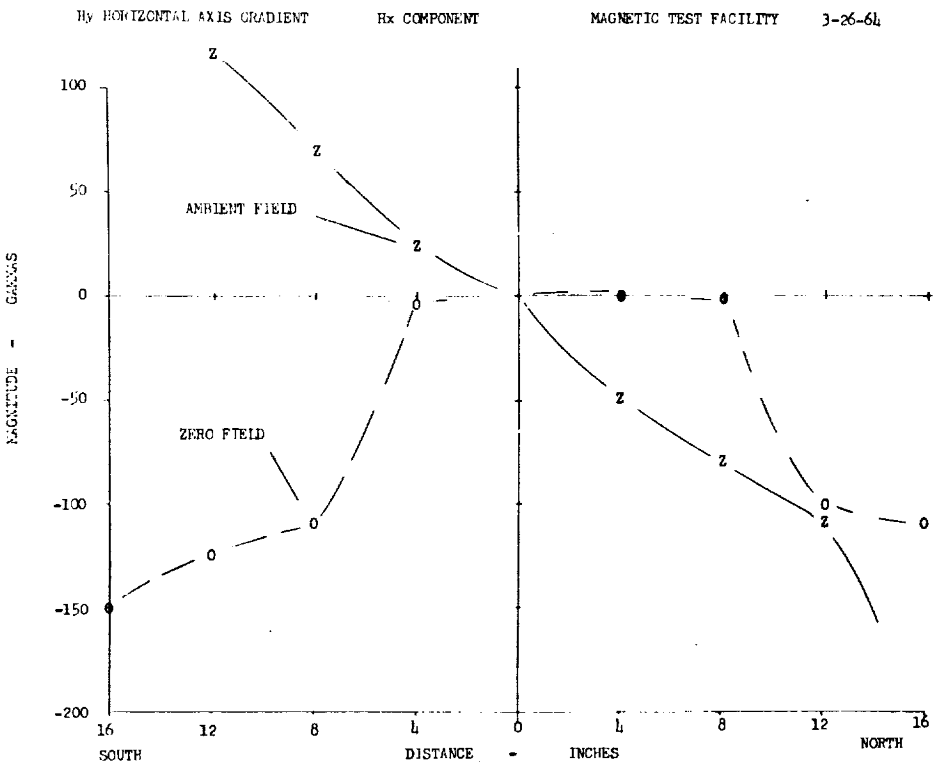

Figure 7–Y Coil Axis – X Component Gradient

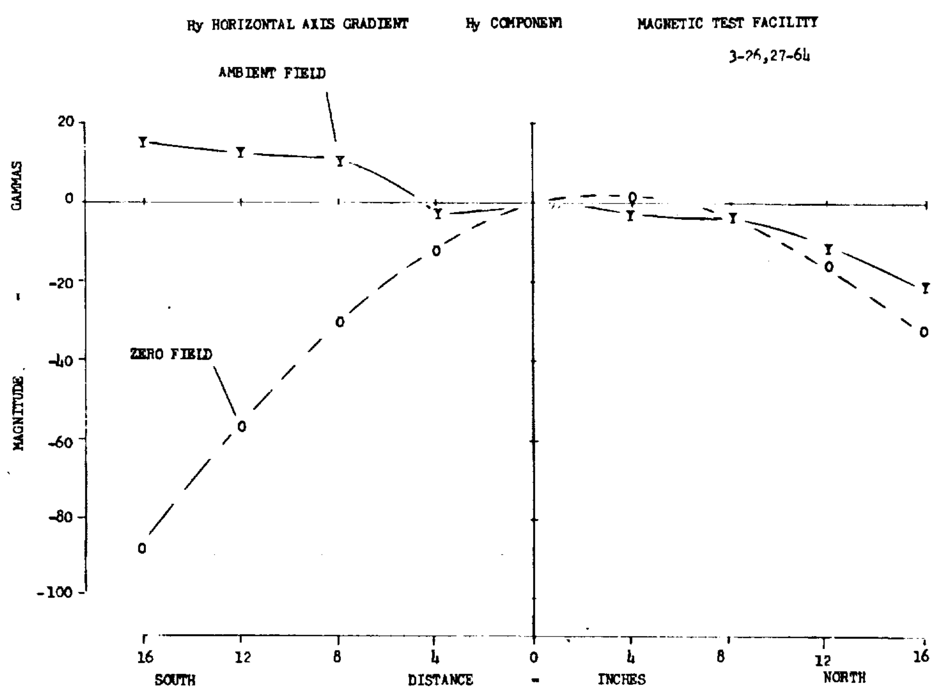

Figure 8–Y Coil Axis – Y Component Gradient

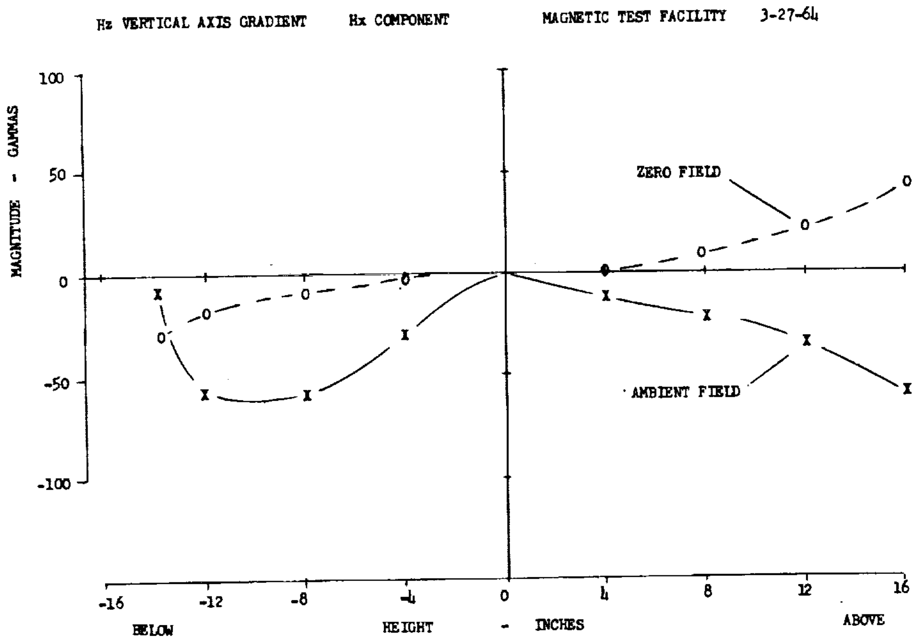

Figure 9–Z Coil Axis – X Component Gradient

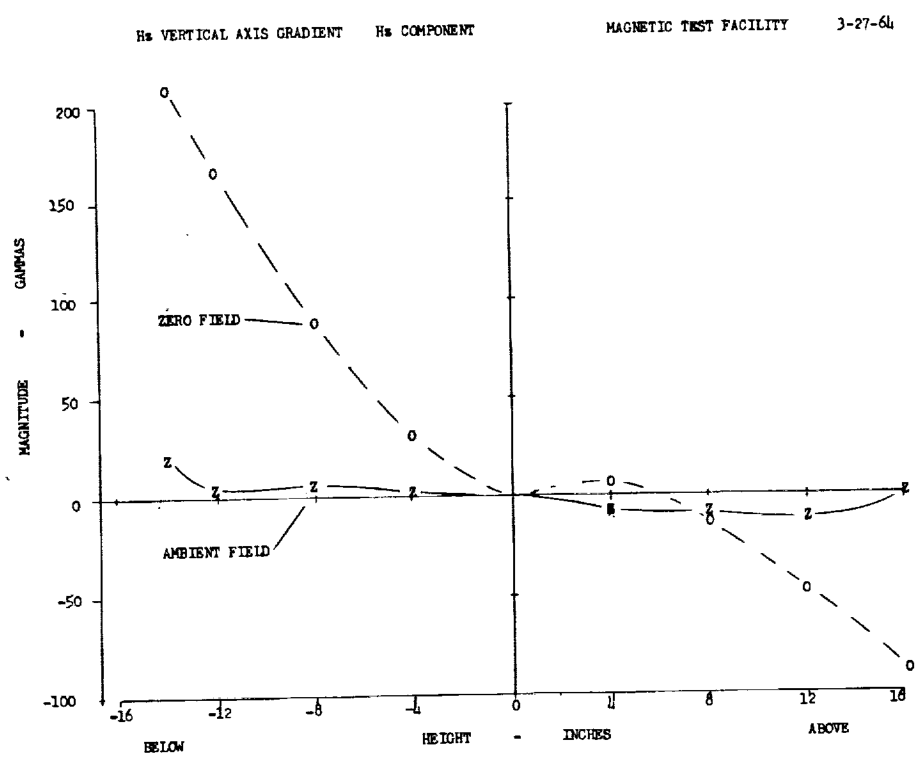

Figure 10–Z Coil Axis – Z Component Gradient

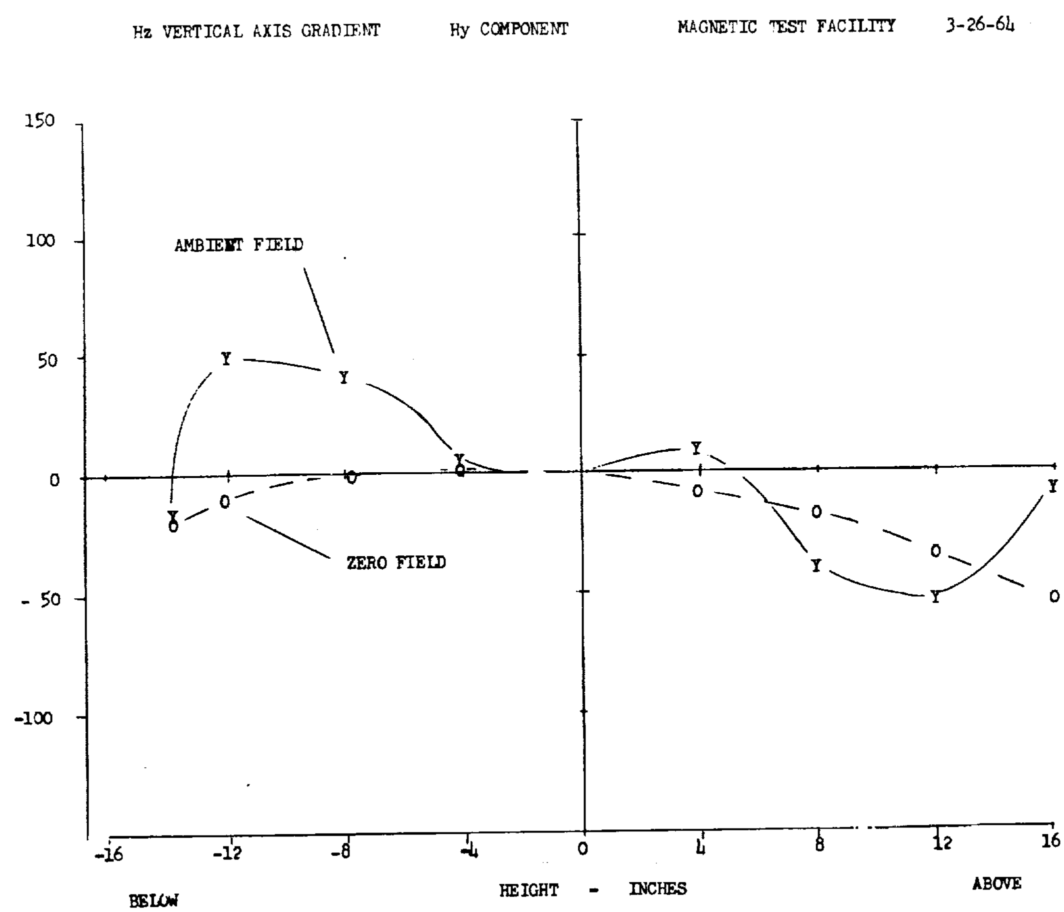

Figure 11–Z Coil Axis – Y Component Gradient

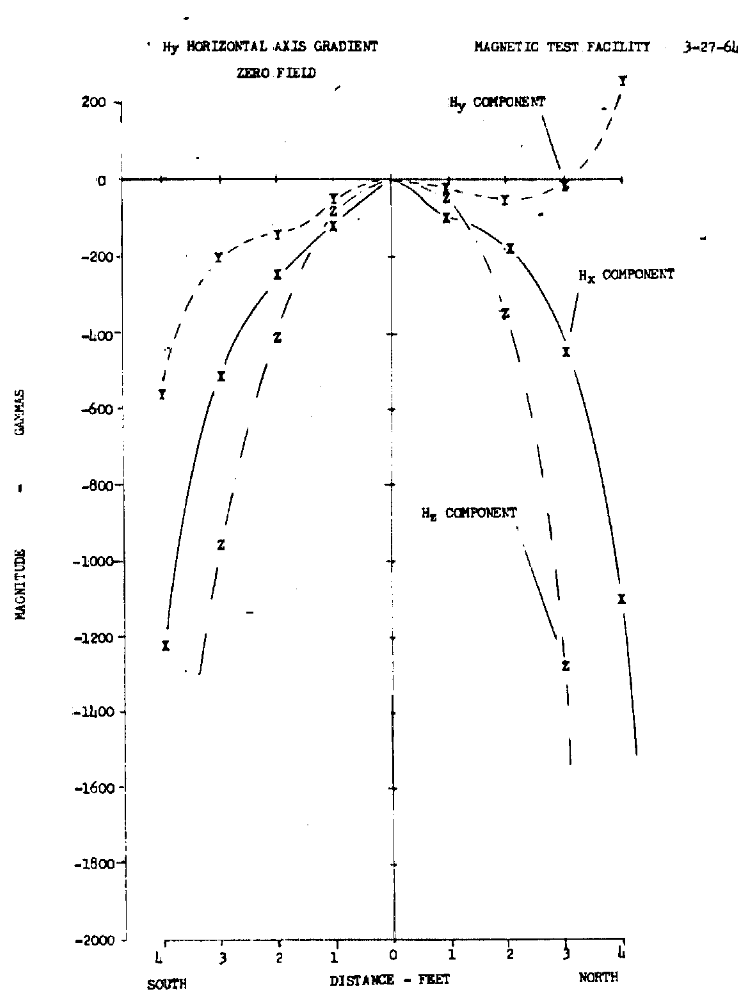

Figure 12—H_y Horizontal Axis Gradient

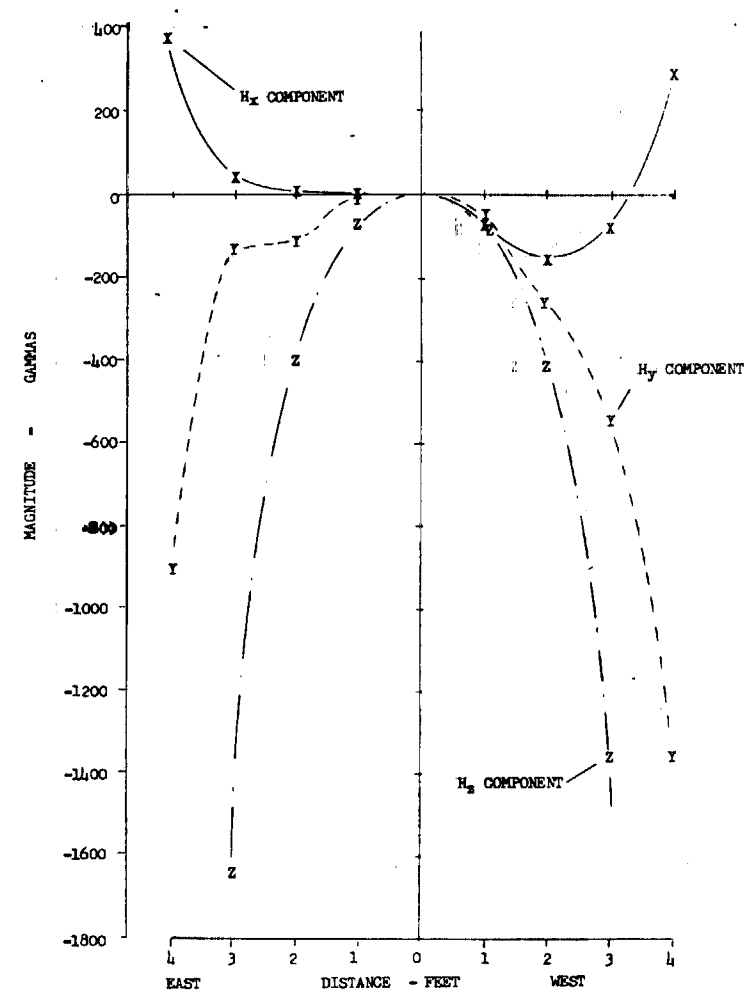

Figure 13—H_x Horizontal Axis Gradient

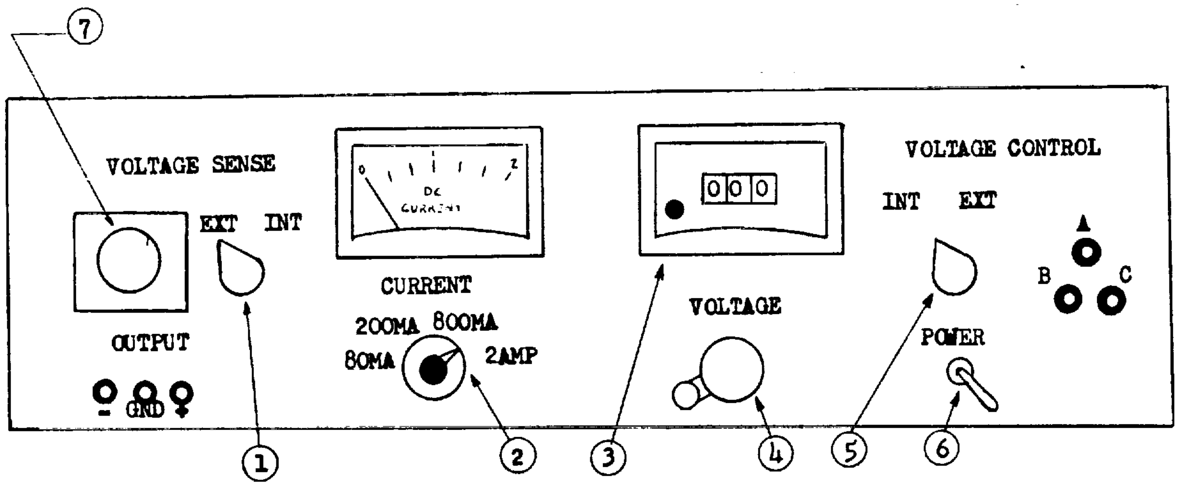

Figure 15–Princeton Applied Research Power Supply Front Panel Layout

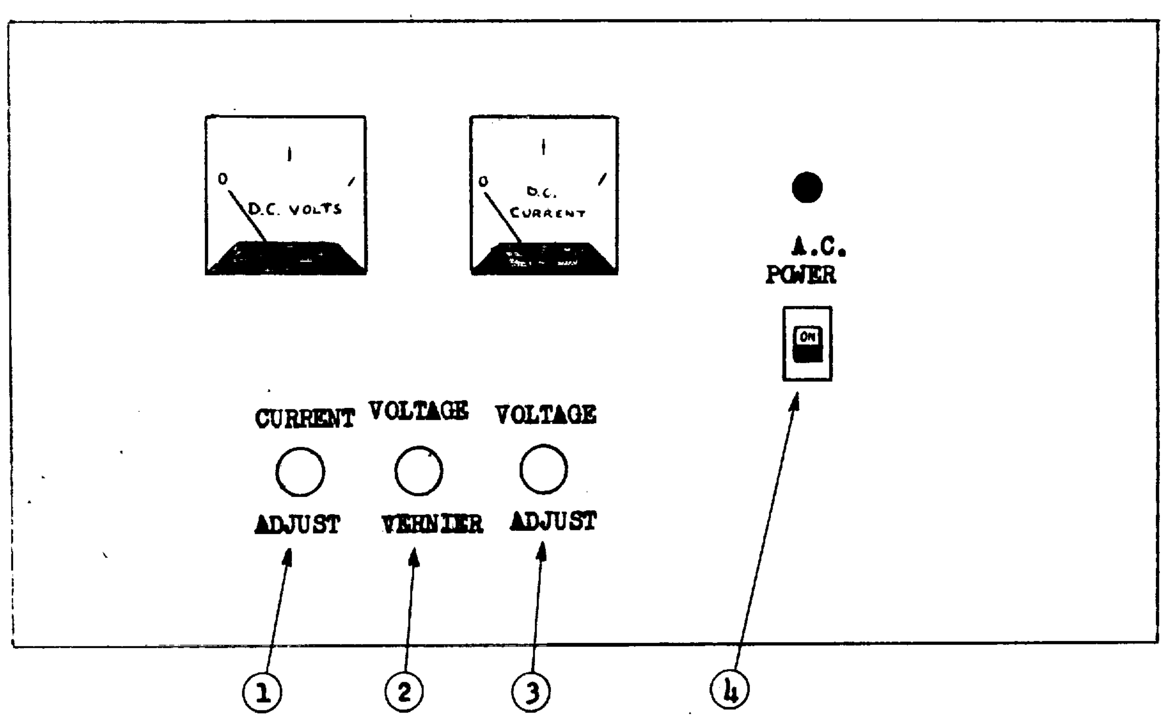

Figure 16–Trygon Front Panel Layout

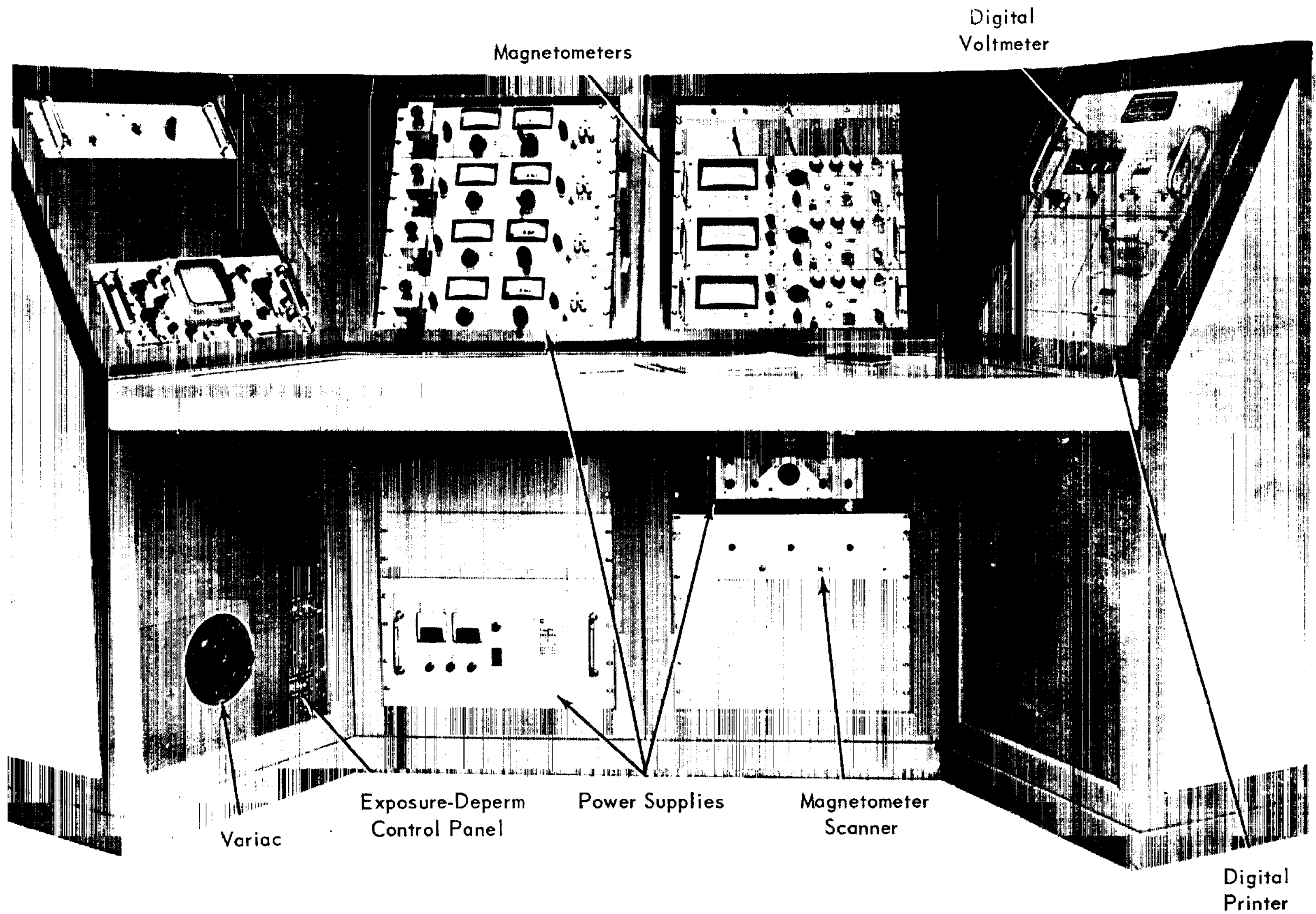

Figure 14–Control Console

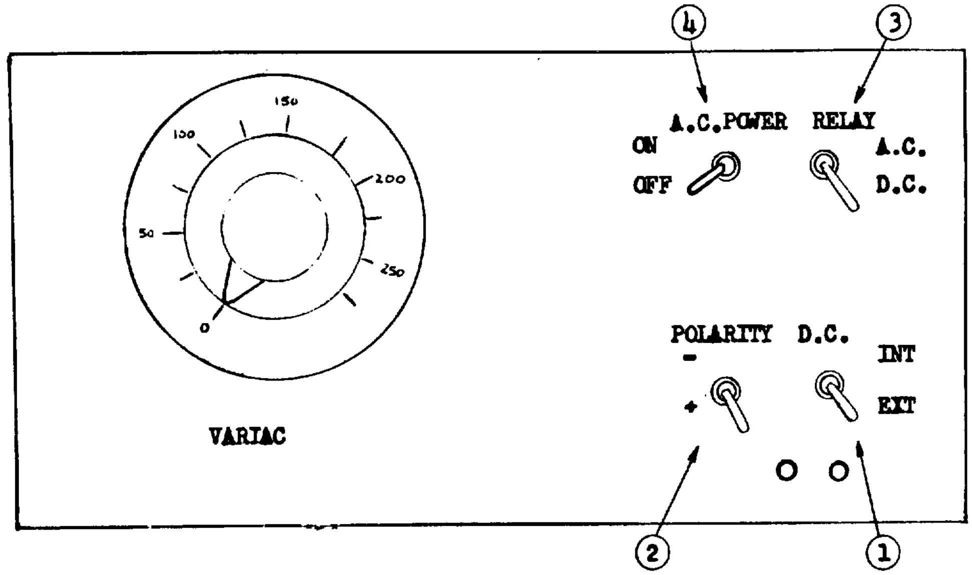

Figure 17–Perm-Deperm Coil Power Output Control Panel Layout

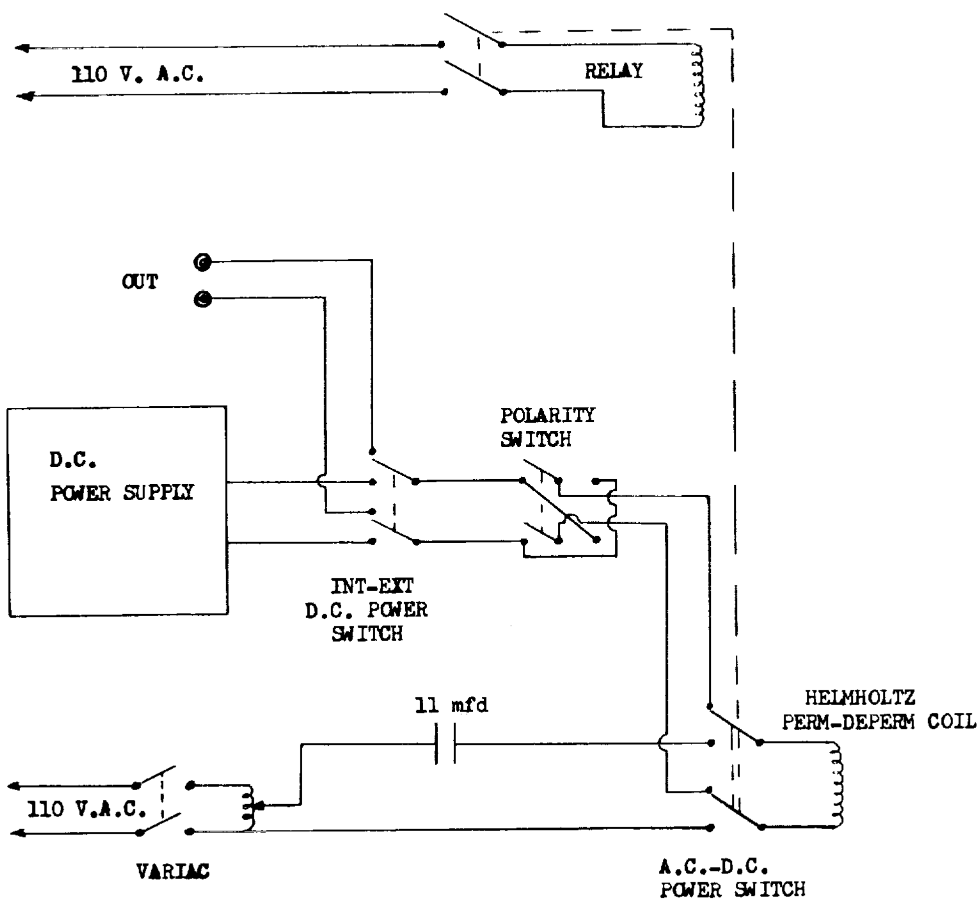

Figure 18–Perm-Deperm Coil Control Circuit

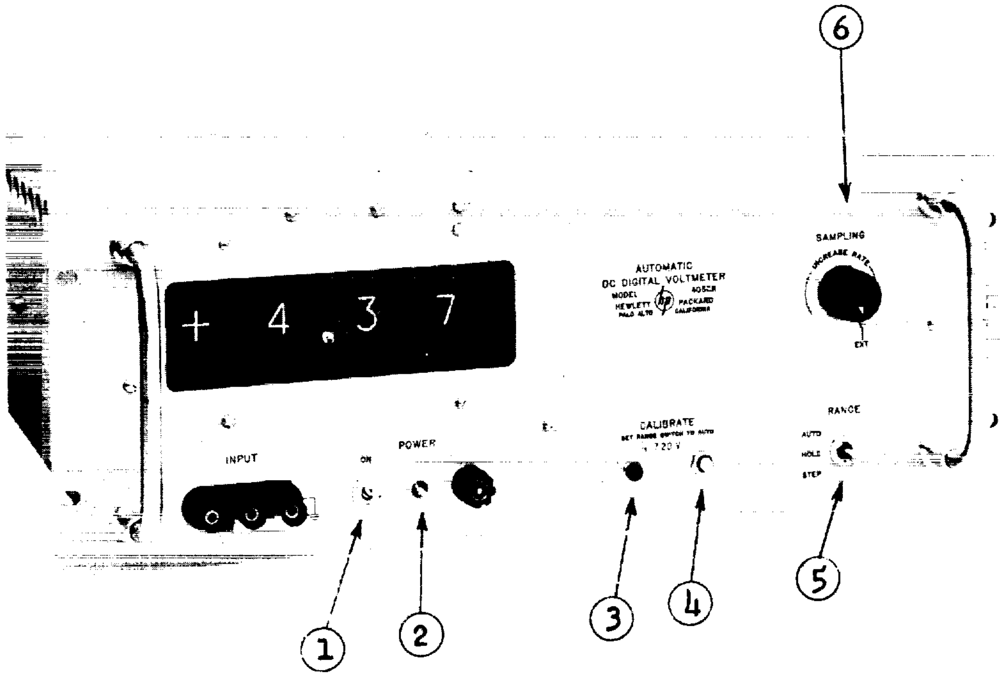

Figure 19–Voltmeter Front Panel Layout

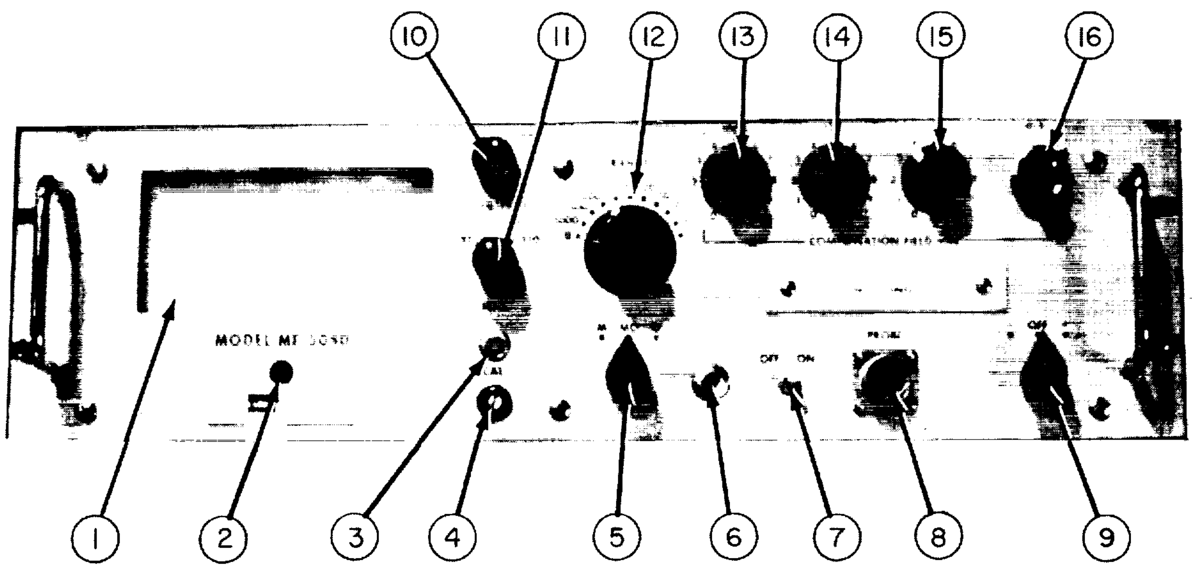

Figure 20–Forster Hoover Magnetometer Front Panel Layout

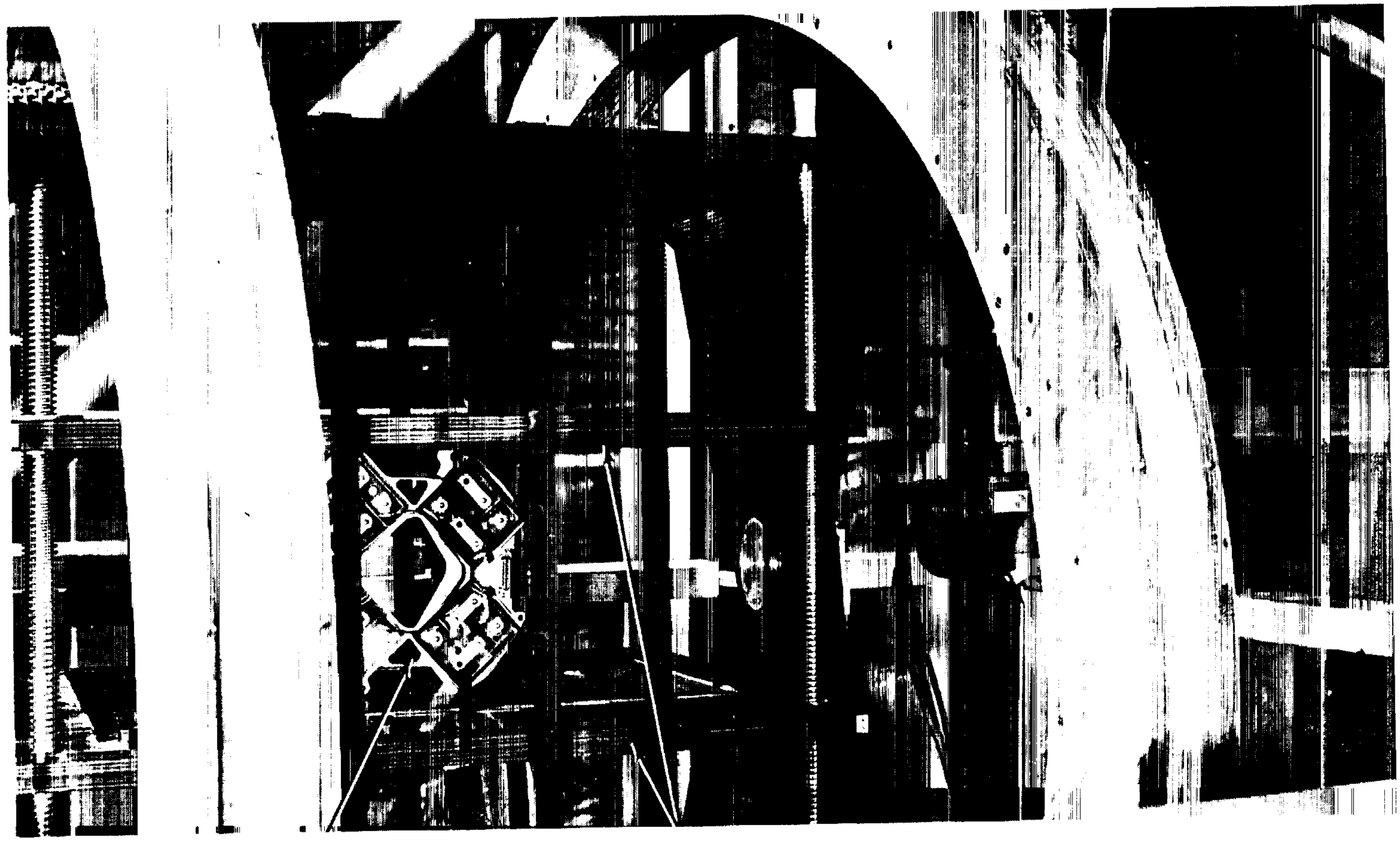

Figure 21–Component Test Arrangement

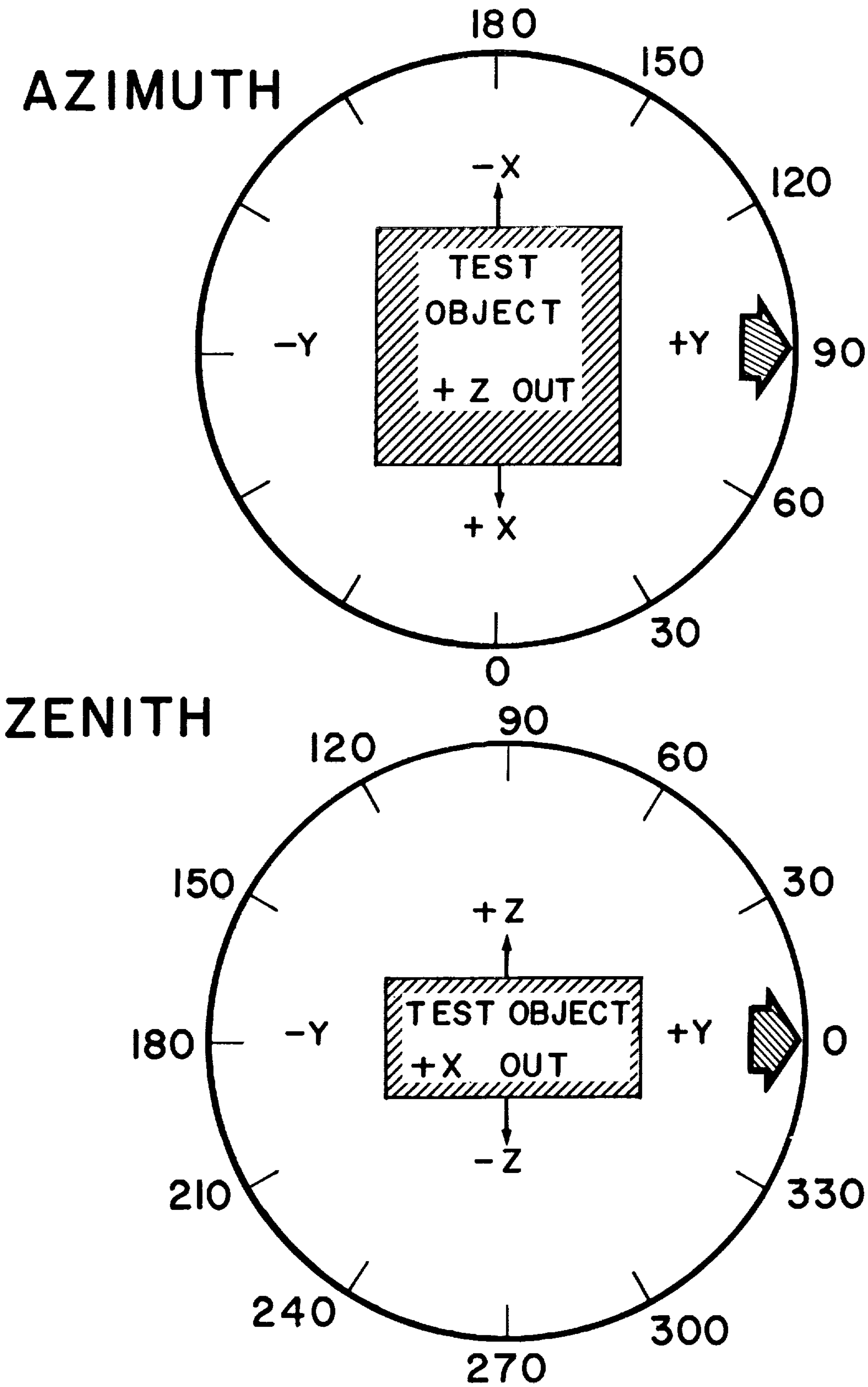

Figure 22–Magnetic Tests Coordinate and Angle Conventions

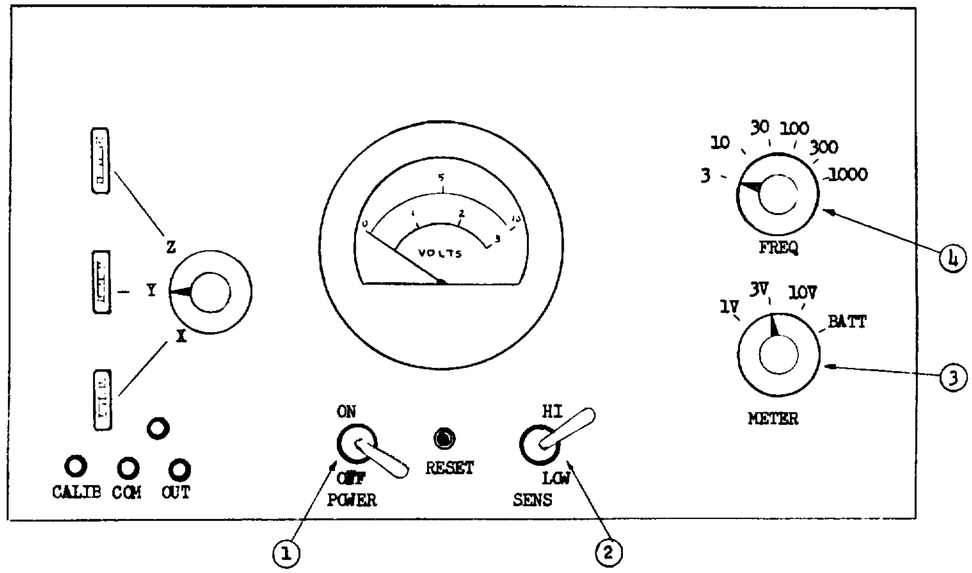

Figure 23–Marshall Laboratories A.C. Magnetometer Front Panel Layout

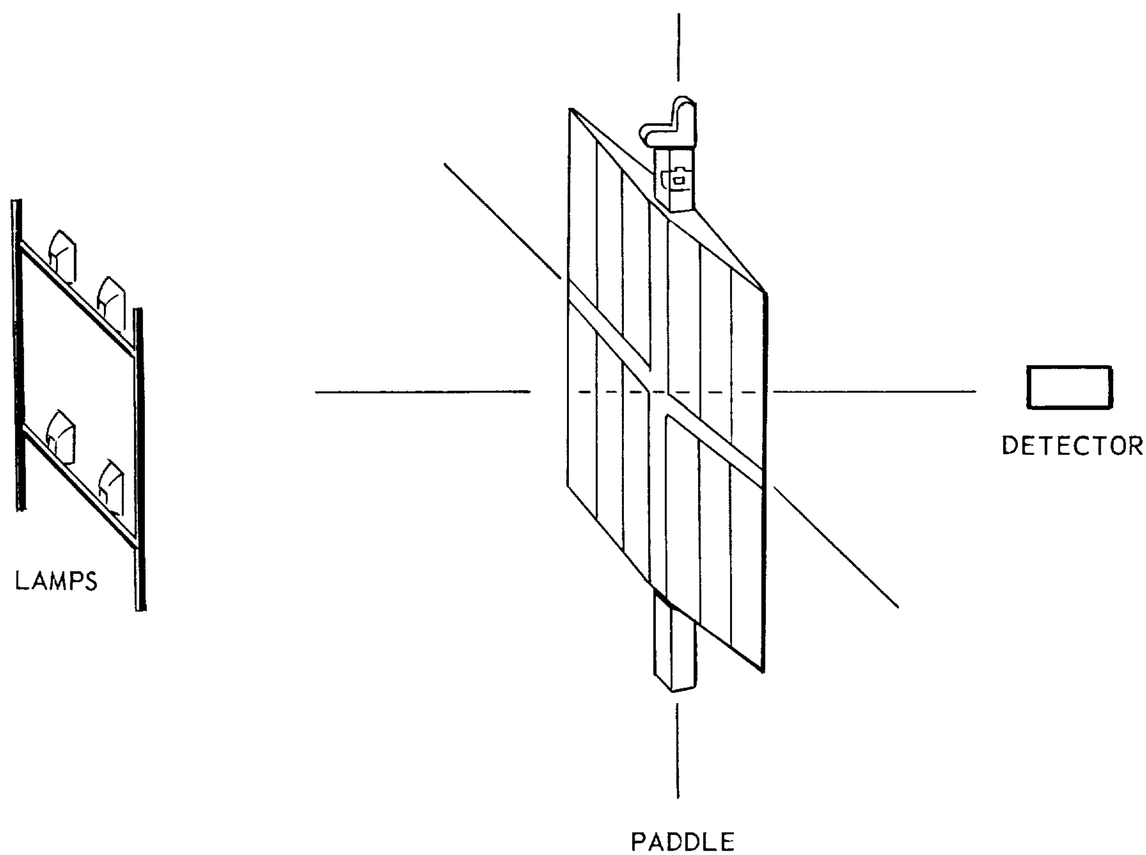

Figure 24–Solar Paddle Stray Field Test Arrangement